INDUSTRIAL ENGINEERING

Application and Operation of
Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

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The Men Who Keep Industry Fit to Fight

. . . Gene Tunney went down in the seventh round in the late Chicago fistic combat under a shower of blows that would have put anyone else to sleep for an indefinite period. But he had something in his possession that enabled him to come back and win the battle. That vital something was perfect condition.

. . . Every athlete knows that when skill or ability are evenly matched, condition is the deciding factor. When the critical moment comes, the muscles, nerves and vital organs of the real champion play their parts with unconscious effort, leaving the brain free to plan the winning strategy.

. . . There is a good deal of similarity, and some differences, between the physical encounter of two ring champions, and the economic battle waged by industrial plants.

. . . The industrial struggle is harder than the meeting of the padded gloves. There is no rest between rounds, no cheering crowds to inspire the fighters to increased effort. Moreover, the training or conditioning of the industrial plant must be done while the battle is going on. And it must go on day after day, year after year unceasingly or until the plant is counted out by the tap-tap-tap of the auctioneer's hammer.

. . . Yet there is great joy in the battle for those who participate in it—great responsibility and opportunity for you who are responsible for keeping our industrial plants in fighting trim.

. . . The champion athlete must have perfect muscular and nervous co-ordination; the ability to concentrate his vital powers immediately. The fighting industrial plant must maintain perfect co-ordination of its electrical and mechanical power transmission systems; its motors and driving mechanisms which form the nerves and muscles of the industrial world. It is a big job to choose the right members; to install them properly in the fighting plant; to keep them fit or to replace them with better or bigger ones when the need occurs.

. . . The champion athlete must have reserves to call upon when the pinch comes. It is a big job to maintain adequate reserves throughout your plant, and to guard continually so that no weak or neglected element may cause unforseen shutdown. For a one-hour shutdown in your plant means a two-hour gain in production by your competitors.

. . . How absurd it would be to expect a man with stiff muscles and hardening of the arteries to compete successfully in a physical contest. Is it not equally absurd to expect the industrial plant to survive the struggle handicapped by poor lubrication and with its traffic arteries clogged through inferior methods of materials handling?

. . . Competition during the coming months will be of increased intensity. More than ever will plant condition be of vital importance to profit making and survival. You men of the Services to Production, you plant engineers, electrical and maintenance chiefs, you master mechanics and materials handling engineers have a big job ahead of you. More power to you, and more power to industry through you!

Fig. 1—Storeroom for maintenance supplies used by the electrical and pipe departments only.

Handling Maintenance Supplies

in the Simmons Company plant

By M. J. SCHMITT
Chief Engineer
Simmons Company, Kenosha, Wis.

THE amount of routine involved in handling and disbursing materials and supplies for maintenance and new construction in an industrial plant is determined to a large extent by the amount, kind, and value of the supplies handled, the frequency of withdrawal, the organization of the department, and the urgency of maintaining uninterrupted production. Modern industrial production demands practically uninterrupted operation, which necessitates stores or supplies adequate to fill any demand for replacement or renewal of broken or worn parts, or other maintenance work, and an arrangement of such supplies which permits quick location and easy access for filling requisitions.

One of the questions always up for discussion in connection with the handling of maintenance stores and supplies is whether such stores should be included with the general plant stores or whether a separate storeroom is advisable. In our case separate stores are provided for the electrical, the mechanical, and the building maintenance departments. Perhaps the principal advantages of having separate stores are that the supplies are located near the department using them, and to fill each requisition does not require a trip to the general stores.

In addition, these stores are accessible to the department at night, on holidays and on Sundays, when the plant and general stores may be closed. It is seldom advisable to permit any except regular storekeepers to have access to a general storeroom. Also, representatives of maintenance departments would not be familiar with the arrangement of supplies in the large, general stores and might have to spend considerable time at night or other times when the storekeeper is away before they found what they wanted.

Before going further into this question of maintenance storekeeping it may be well to describe briefly our organization, because our plan of handling stores is closely tied in with our maintenance activities.

Maintenance at the Kenosha plant of the Simmons Company is taken care of by three departments. Millwright, carpenter and allied work is under the direction of the building superintendent. The machine shop and toolroom are under the supervision of the master mechanic. The electrical and pipefitting work and power department are under my direction. Each of these divisions has control of its own stores. These separate maintenance stores are in reality, however, branchs or departmental subdivisions of the general stores. The method of handling these stores in the three departments varies slightly, but in general all three fol-

low about the same plan of organization and operation. Therefore, only the methods followed in the electrical and pipe departments will be described here.

The shops and headquarters of the electrical and pipe departments are located adjoining each other, which simplifies supervision and also makes it possible to use one storeroom as in Fig. 1, and one combination clerk and storekeeper.

The staff of the electrical department is composed of one foreman, two wiremen, one motor inspector, one day trouble man, one armature winder, who also inspects and repairs controllers on elevators, one night trouble man, one day trouble and repair man in the rolling mill, and one clerk who also serves as storekeeper.

The pipe department has one foreman, six pipefitters, one shopman, one day and one night trouble man, one heat man who takes care of pumps and steam traps in the winter and one night heat man.

Incidentally, in the same section of the building are the headquarters for the plant fire department which is made up of men from the electrical and pipe departments. Generally, several of these men, enough to answer fire calls, are in or close to the departmental shops at all times. The night electrical and pipe trouble men are also members of the night fire department.

The plant is engaged in the manufacture of metal beds, metal furniture, springs, and mattresses. Approximately 900 motors, ranging from 3 hp. to 750 hp. in rating are installed in the plant. About 450 of these motors, including the fractional-horsepower sizes, are below 3-hp. rating. The largest motors, however, are used to drive equipment in the rolling mill. Practically all the motors with the exception of some fractional-horsepower units operate on 440-volt, 60-cycle, three-phase a.c. circuits. Some of the fractional horsepower motors are operated on 110-volt, single-phase a.c. circuits and others on 110-volt, direct-current lines. Two motor-generator sets supply power for the direct-current cranes, switch operation, electrical stops on important machinery, and some other uses. Synchronous condensers are used for power-factor correction.

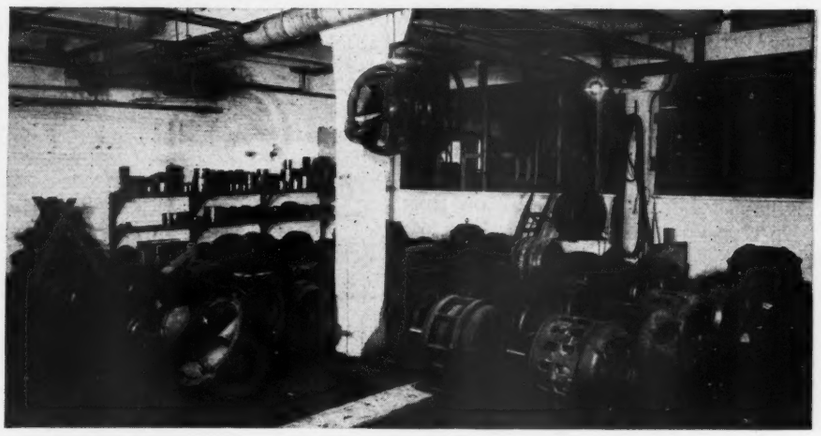


Fig. 2—Storage space for surplus equipment, spare motors and pulleys. Equipment marked × is for sale or disposal. Motors carrying a tag are spare motors for a particular installation. Other motors without tags are spares available for use wherever a motor of that size will fit. Motors are handled in and out of the room by a chain hoist on a monorail trolley.

Because of the comparatively small amount of direct-current equipment, motor repair is a small item. However, we make practically all coils needed for rewinding motors, and transformer coils for special welding machines. It is usually necessary to make the motor coils on special order instead of carrying them in stock. Bearings are made up in the machine shop and any other necessary machine work is done there on requisition. We have drill presses, a lathe, shaper, and pipe-threading machines in our electrical and pipe departments; so we are able to make many of the smaller repairs or make minor repair parts not carried in stock.

As stated previously, our electrical stock, pipe fittings, and supplies for repair, renewal, maintenance, and new construction work are carried in the same storeroom. Storage space for surplus equipment is shown in Fig. 2. A clerk issues stock on requisition from either department, maintains a stores record of receipts and disbursements and, in addition, receives trouble calls for both electrical and pipe trouble men. These calls are entered on large Daily

Fig. 3—This daily trouble report sheet lists all work handled by the trouble man. The clerk who handles the stockroom also receives all trouble calls which are listed on this report. When the trouble man clears an interruption to service, he reports here the time he returns to the office and the nature of the trouble. These reports are filed for future reference. The abbreviation "ooo" means "out of order."

FORM 1941—1M-2-26
SIMMONS COMPANY

DAILY TROUBLE REPORT 7-18-27 DEP'T 192

DEPARTMENT	TROUBLE	BLDG.	FLOOR	TIME REPORTED	TIME CLEARED	NATURE OF TROUBLE	REMARKS
Mattress	String lights ooo	39	6	8:35	9:05	OK Wire grounds, fuse out	
Coil Spring	Motor ooo	38	5	10:10	10:25	Down on bearings, to be taken out	
Steel Tube	#14 Spot Welder ooo	60	1	10:20	11 05	OK. Contacts burnt out in Oil Switch	
Coil Spring	Connect Motor	38	5	11:25	11:40	OK.	
		7-	21	-27			
Steel Tube	#1 Saw Machine ooo	60	1	7:05	7:25	OK. Main fuse out on line	
Steinway	Light ooo	90	1	8:35	8:50	OK Bulbs burnt out	
Mt + Pkg	Spring lights ooo	33	5	10:15	10:35	OK Loose Connection in Switch	
Coil Spring	Lights ooo	38	4	10:45	11:15	OK Shell on Socket broke.	

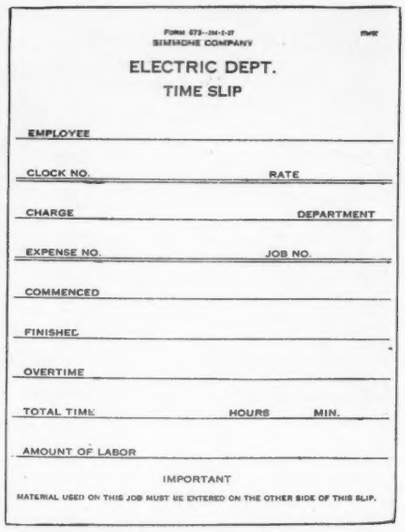
Trouble Reports listing the department, the nature of the trouble reported, the building, floor, and time reported. One of the trouble report forms for the electrical department is reproduced as Fig. 3. The form used by the pipe department is quite similar. The symbol "ooo" on this report is an abbreviation for "out of order."

If the trouble man is in the office he goes immediately to clear the trouble. If the call indicates the interruption of work in any step in the process or that it is holding up a large number of men, the armature winder or any other electrician who may be in the department is sent out. These men are so familiar with the work in the different departments that they usually know from the nature of the call what supplies to take. Incidentally, they make up various assemblies of supplies which enable them to clear troubles more quickly.

After clearing a case of trouble the men return to the office and make a report showing the time that they return, the nature of the trouble, and such information as they can give about the cause of other conditions.

These report sheets when filled are sent in to my office for study and are then filed. At the end of the day the trouble man makes out his Time Ticket, Fig. 4, from the trouble report, and enters on it any material used. A separate time ticket is made for each department against which work and material are to be charged. When several calls are made to one department in a day, the totals are grouped on a single time ticket.

Material Records, Fig. 5, are kept on all materials carried in our stockroom. The practice of entering each item as distributed is followed in connection with the operation of some stores departments. Because much of the material and supplies is issued in small quantities of one, or at most a few units, at a time to the trouble men, that task of entering the disbursements on the card for each issue of supplies would fill the card in a short time and entail a large amount of clerical work. Instead, when the weekly Report of Stores Used, Fig. 6 is filled out, the clerk quickly totals the amount of each item disbursed and enters this weekly total on the Material Record, Fig. 5 shown on this page.



Form 673—3M-1-37 SIMPLEX COMPANY

ELECTRIC DEPT.
TIME SLIP

EMPLOYEE

CLOCK NO. RATE

CHARGE DEPARTMENT

EXPENSE NO. JOB NO.

COMMENCED

FINISHED

OVERTIME

TOTAL TIME HOURS MIN.

AMOUNT OF LABOR

IMPORTANT

MATERIAL USED ON THIS JOB MUST BE ENTERED ON THE OTHER SIDE OF THIS SLIP.

Fig. 4—Workers in the electrical department report their time on this slip. For example, at the end of the day the trouble man makes out a record of his time, charging the work he has done to the various departments and also entering the material used on the back of the slip. The same is done by other workers in this department.

The material used is reported to the general stores department weekly on the Report of Stores Used Sheet, Fig. 6. This report shows the quantity of each item used, the department to which it is to be charged, the name or description of the article, and the account or job number to which the supplies are to be charged. Pricing is done by the stores department and the costs distributed by the accounting department.

We do not keep a running balance on the Material Record card. Our amount of stock and the number of items is so small that the clerk can easily tell by observation when the stock of any item gets low. If, for any reason, a balance is wanted it may be taken from the cards in a moment. This practice, I realize, could not be followed in a stores department handling large quantities and varieties of material, or where responsibility could be placed on more than one man. However, these are only branch or departmental stores. The principal inventory records are maintained by the general stores department, whereas our departmental stores records are maintained more for our own convenience and do not need to be so complete.

Ordinarily, we try to keep our inventories low. Whenever we know that a special new construction or rearrangement order is coming through the material necessary is ordered through the general stores department, which charges it to our electrical stores, if one is issued. Then, when the material is used, it is charged against the job number on

Figs. 5 and 6—A card record is kept of each class of material on hand and a weekly report made of material used. A separate card is used for each item of stock. All of the receipts are entered at the right and disbursements entered weekly at the left. Each week the clerk makes up this Report of Stores Used in the electrical department and shows the quantity and department or account to which it should be charged. The totals of each of the materials are entered on the proper Material Record card.

SIMMONS COMPANY
MATERIAL RECORD

MATERIAL No. 14 R.C Wire INV. 250

12-18	881	3-18	856	12-3	2500
12-25	726	3-25	450	12-13	2500
1-8	778	3-31	1070	1-24	10000
1-15	338	4-8	524	4-4	10000
1-22	1678	4-22	598	5-31	5000
1-28	973	4-29	324	7-2	10000
2-4	532	5-6	276		
2-11	502	5-13	554		
2-18	314	5-22	7163		
2-18	70	6-3	428		
2-25	610	6-10	454		
3-4	620	6-24	280		
3-11	178	7-15	5544		

Form 1985—3M-3-28 SIMMONS COMPANY

REPORT OF STORES USED No. 100

Electric DEPT.

WEEK ENDED 7-22 1927

INSTRUCTIONS—
TO BE PREPARED WEEKLY IN DUPLICATE BY FACTORY SERVICE DEPTS. TO REPORT STORES USED BY THEM OUT OF STOCK IN THEIR POSSESSION. DO NOT USE FORM 1270 FOR THIS PURPOSE. WHEN THE END OF THE WEEK AND THE END OF THE MONTH DO NOT COINCIDE PREPARE A SEPARATE REPORT FOR EACH PART OF THE WEEK. NUMBER SERIALLY FROM ONE UP.

QUANTITY	CHARGE S.O. ORA/C NO.	CHARGE DEPT. NO.	ARTICLE	UNIT	PRICE	VALUE
12	206	27	60 W. Globes			
6	206	17	150 W. "			
1	Bagway	7-14-27	R # 30965 - M.S.	20	Supp. Switch	
30ft	303	35	1/2" Conduit			
2	206	Street	150 W. Globe			
			Found			
1	"	"	1/2 x 3/4 3 hole Pipe		Corner	
1	306	66	#5814 Hunter		Chain Fixture	
1	"	66	300 W Globe			

FOREMAN'S O. K. [signature]

the Weekly Report of Stores Used, Fig. 6. Requisitions on general stores for ordering special supplies are issued from my office in the form of memorandums. Ordering stock for replenishment is handled automatically through my office.

When not answering calls, the night pipe trouble man makes pipe nipples which are turned over to the clerk who counts and checks them into stock in the same manner that other material received is handled. This man also cuts and threads pipe and does much other useful work on new construction jobs for the next day. The night electrical trouble man also gets electrical work which must be done in the shop, ready for the next day. Both of these men have access to our storerooms at night. The maintenance storeroom and repair shop Fig. 7, are in the same section, wherein, equipment for bending and threading conduit and an electrically-heated armature and coil baking oven are located.

We also keep our own motor and control record which is filed by buildings and subdivided by floors. Thus, whenever a motor is reported down, the trouble man can check the size and other information on the motor and control before going to the job, and so be more likely to take the necessary supplies with him.

Whenever a motor is moved, the millwright or electrician handling the job reports this to the electrical department on the Motor Transfer Notice, Fig. 8. This transfer is reported to the accounting department and head office on the Machinery-Tools-Equipment Transfer Notice, Fig. 9. This latter notice is used in connection with the inventory and depreciation record which is kept according to the Simmons Equipment No. in the upper right hand corner of this report. For this reason every machine carries a brass tag which has its Simmons No. on it.

Convenience and accessibility to stores and supplies, with as little routine and clerical work as necessary are, we believe, the essential elements in connection with maintenance stores. The method we use is very satisfactory, is tied in carefully with the organization and operation of the department, and incurs only the amount of routine necessary to keep the stores in order and to know what we have on hand.

SIMMONS COMPANY

MOTOR TRANSFER NOTICE

EQPT. NO.

DATE 192

MAKE

H. P. SERIAL NO.

SPEED

MOVED FROM BLDG. FLOOR DEPT.

TO

SIGNED

SIMMONS COMPANY

TRANSFER NOTICE EQPT. NO.

MACHINERY-TOOLS-EQUIPMENT

DATE 192

DESCRIPTION

TRANSFERRED FROM BLDG. FLOOR DEPT. LOCATION

TO

SCRAPPED, DISCARDED, SOLD REASON:

RECORDED APPROVED

FACTORY ACC'T DEPT.

H. O. NUMERICAL FILE

H. O. CLASSIFIED FILE

Figs. 8 and 9—Transfers of equipment are recorded on these notices. Whenever a motor is moved, it is reported to the electrical department on the form shown at the left. The head of the electrical department then reports this transfer on the Machinery-Tools-Equipment Transfer Notice at the right, so that the main office is able to keep account of all machinery or equipment charged against the various departments.

Fig. 7—Supplies of wire and conduit are also carried in the storeroom. The maintenance storeroom and the repair shop are in the same section. Equipment for bending conduit is shown on the bench in the foreground. An electrically-heated armature and coil baking oven is located in the background at the right.

Announcing the National Power Show

THE Sixth National Exposition of Power and Mechanical Engineering will be held at Grand Central Palace, New York, N. Y., from Dec. 5 to 10, inclusive. The annual meetings of the American Society of Mechanical Engineers, and the American Society of Refrigerating Engineers, as well as numerous other organizations will be held at the same time as the exposition; some of these will meet jointly with, or in bodies, attend the exposition.

It is expected there will be numerous exhibits of materials handling equipment, transmission equipment, and mechanical exhibits of all kinds, which will lead the way to the complete equipment of every industrial plant.

The managers report that the exposition will this year occupy four full floors of the Grand Central Palace and that excepting a few spaces still available all space is engaged. All inquiries should be addressed to the International Exposition Company at the Grand Central Palace, New York, N. Y.

Applying

SAFETY

To Plant Operation

THE sixteenth annual Safety Congress which was held at the Stevens Hotel, Chicago, Sept. 26-30, under the auspices of the National Safety Council drew an interested attendance of approximately 5.000 people.

The principal officers of the National Safety Council for the coming year are as follows: President of the council, H. E. Niesz, Commonwealth Edison Co., Chicago; treasurer, T. G. Hellmuth, Chicago, North Shore & Milwaukee Railroad Co.; managing director, W. H. Cameron, Chicago; vice-president for industrial safety, E. W. Beck, U. S. Rubber Co.; vice-president for public safety, Miller McClintock, Harvard University; vice-president for engineering, G. E. Sanford, General Electric Co.; and vice-president for health, Prof. C. E. A. Winslow, of Yale University.

The good work which has been accomplished in accident prevention is indicated by the decrease in industrial accidents in practically all industries. It was stated at this meeting that if all the information and knowledge of unsafe conditions and practices were applied and taken advantage of by every individual interested that practically 90 per cent of the accidents could be eliminated. Organized safety work must be given credit for much of this advancement.

Cost of Accidents

When discussing the cost of accidents, H. W. Heinrich, assistant superintendent, The Travelers Insurance Co., stated that compensation payments (compensation and medical payments) constitute only one-fifth of the total employer accident cost. The incidental cost is estimated at four times the compensation cost.

In the meeting held by the Engineering Section, American Society of Safety Engineers, especial attention was given to the discussion of the reports of the Research Committees on Wire Rope Attachments and Connections, Effect of Annealing on Chains, and Elimination of Harmful Noise. All of these were preliminary reports outlining the tests and other research work which should be made. The chairmen of the various committees urged that safety and operating men give the committees the benefit of their experience. This may be addressed to the respective committees in care of the National Safety Council, 108 E. Ohio Street, Chicago, Ill.

Briefly, the work outlined by these committees is as follows: The Committee on Wire Rope Attachments and Connections plans to make tests of the reliability of the various types of attachments and connections and of the methods of applying them. Particular study is to be given on reliability. The Committee on Elimination of Harmful Noise is studying the effect of noise and endeavoring to determine what noises are the most harmful.

The importance of safety is well understood when it is realized that of approximately 90,000 fatal accidents in the United States during 1926, some 24,000 were among the workers in industrial plants. The number of injured runs into the hundreds of thousands annually.

The Committee on Effects of Annealing Chains is to make a study of annealing at various temperatures to try to determine whether annealing is worth while and, if so, the temperature and treatment which will give the best results. The interesting conclusions of a group of British engineers who were investigating the cause of chain failures was included in the report. This group stated that chain failures resulted from overloading, defects in manufacture, and advanced a theory that the sudden breakage of an apparently good chain was due to a brittleness, or so-called "crystalization," of a thin skin on the surface of the link resulting from the light surface impacts of handling; a small crack in this brittle skin is supposed to be the start of the break. The work of these committees will be watched with much interest.

"In general, the cause of all fires is improper maintenance," was the startling statement of Benjamin Richards, Manager, Underwriters' Service Association, Chicago, Ill. "In most industrial plants the general maintenance or upkeep departments have charge of heating, lighting, arrangement of power drives, and such other features as may include the causes of all, so-called, 'common-hazard fires.'" Mr. Richards then pointed out that with the increase in size of the plant and the complexity of its management, the men who control the expenditures are far removed from the intimate knowledge of the requirements and so it is more difficult to obtain their approval to appropriations for much above the absolute essentials for the proper protection of the plant.

Mr. Richards emphasized the hazard of the modern industrial plant of a single large area under one roof and without division walls containing a wide variety of processes and the resultant special hazards. Especial care must be given to housekeeping, packing and other inflammable material, wood construction and other flame feeding materials in such construction.

Reducing Fire Hazard

In a paper entitled, "Relation of Plant Housekeeping to Fire Hazards," Eugene Arms, Mutual Fire Prevention Bureau, Chicago, Ill., stated that, "cleanliness is all important to fire protection. A match or cigarette thrown on a clean wooden floor will not ignite it. When the fire spreads so rapidly that all exits are cut off, nine times out of ten the cause is bad housekeeping. Plant cleanliness creates careful employees.

Walter C. Wagner, of the Philadelphia Electric Co., Philadelphia, Pa., presented a paper "Prevention of High Voltage Hazards in Industrial Substations." A synopsis of his paper appears on page 525 in this issue of Industrial Engineering.

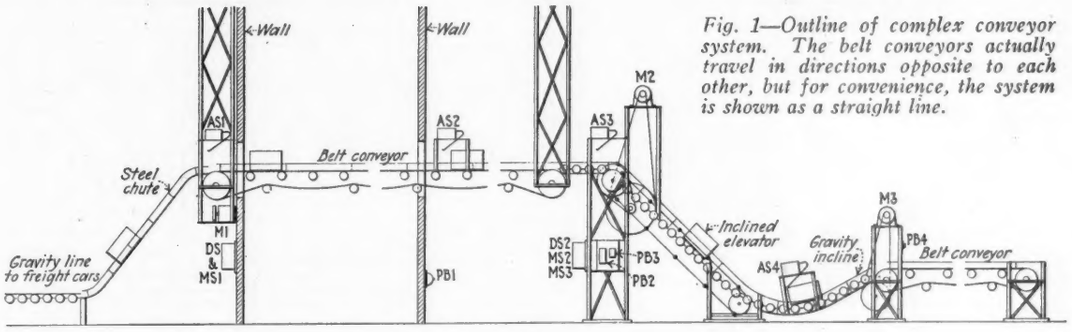


Fig. 1—Outline of complex conveyor system. The belt conveyors actually travel in directions opposite to each other, but for convenience, the system is shown as a straight line.

How a Complex Conveyor System Was Magnetically Controlled

By P. T. VAN BIBBER
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THE USE of magnetic switches to control both small and large motors from remote points is becoming more common each year, therefore, it is the purpose of this article to set forth a rather unusual method of making this type of switch serve also as a sort of automatic block-control system on a conveyor installation.

Necessity is usually the real instigator of any novel departure from the regular ways of installing any mechanical or electrical contrivance and such was the case in this installation. The conveyor system, as shown in Fig. 1, was installed to handle empty wooden boxes from the rear of three bottle-washing machines to a line of freight cars on the other side of the building, a total distance of 350 ft.

After a box had been unloaded at any of the machines it was thrown onto the belt conveyor section shown at the right. At the end of this first belt section was an inclined gravity roller section, dropping down to the base of an inclined elevator and at the same time curving around 180 deg., so that this elevator lifted the empty boxes to an elevation of about 12 ft. again and the second section of belt conveyor carried them over the three machines through a a separate process room and into a warehouse for storage, where the boxes were dropped down again by means of an inclined steel chute. From here another section of gravity roller conveyor carried the empty cases across the warehouse, a distance of about 150 ft., to the loading platform where they were again lifted into freight cars by means of a second inclined elevator, for reloading with bottles.

When first installed, the motors driving the two belt conveyors and elevator were fitted with magnetic switches, having ordinary push-button control of the "safe-stop" type, located near each unit so controlled. Before the system had been in operation many hours it became quite evident that an operator would have to be maintained at each motor control if delays were to be avoided. These cases from frequent handling often had broken pieces of the bottom or sides catch on a guard rail support or roller. When this happened the line would be blocked at that point and, if the units just behind the jam were not soon stopped, boxes would be piled on the floor.

The first improvement was to install an automatic stop for each section, as shown on the drawing at *AS1, AS2,* etc. These were made by mounting a standard make of hatchway limit switch above the conveyor line at each point and fastening an inclined arm to each switch of proper length, so that a box would easily pass underneath if in right position but would cause the switch to open if the box came along on end, yet could still pass under without jamming. The first point of trouble was at the end of the curve entering the first elevator, where occasionally a broken side of a box would catch on the guard rail and hold up the line. The first automatic stop switch, therefore, served to stop the motor driving the first belt conveyor section. As soon as the case on end was removed and the limit switch allowed to drop to normal position the belt would immediately start up again.

The next point of trouble was at the top of the elevator, where a box might become up-ended by the conveyor-chain cross bars catching on a broken bottom board. The lifting of the switch arm *AS3* would immediately stop the elevator and, although the gravity section leading to the second belt was only inclined so as to require one box pushing another to reach the belt beyond, the offender went no further until righted and pushed along by hand. About 50 ft. further at the top of the elevator ahead, another stop switch, *AS2,* was installed, in series with the one at the end of this belt section. The long belt line stopped, if either switch was lifted slightly.

The installation of these safety-stop switches, however, only served to shut off the driving power of the section on which each was installed. It did not prevent further jamming up of cases from the units ahead, which continued to run when either the elevator or long belt section stopped. It became evident, therefore, that some automatic means must be provided to also stop the units ahead of where the trouble occurred so, the interlocking system, as shown on the accompanying wiring diagram was developed and put into operation. For the safety of employees, the starting button was located at the ele-

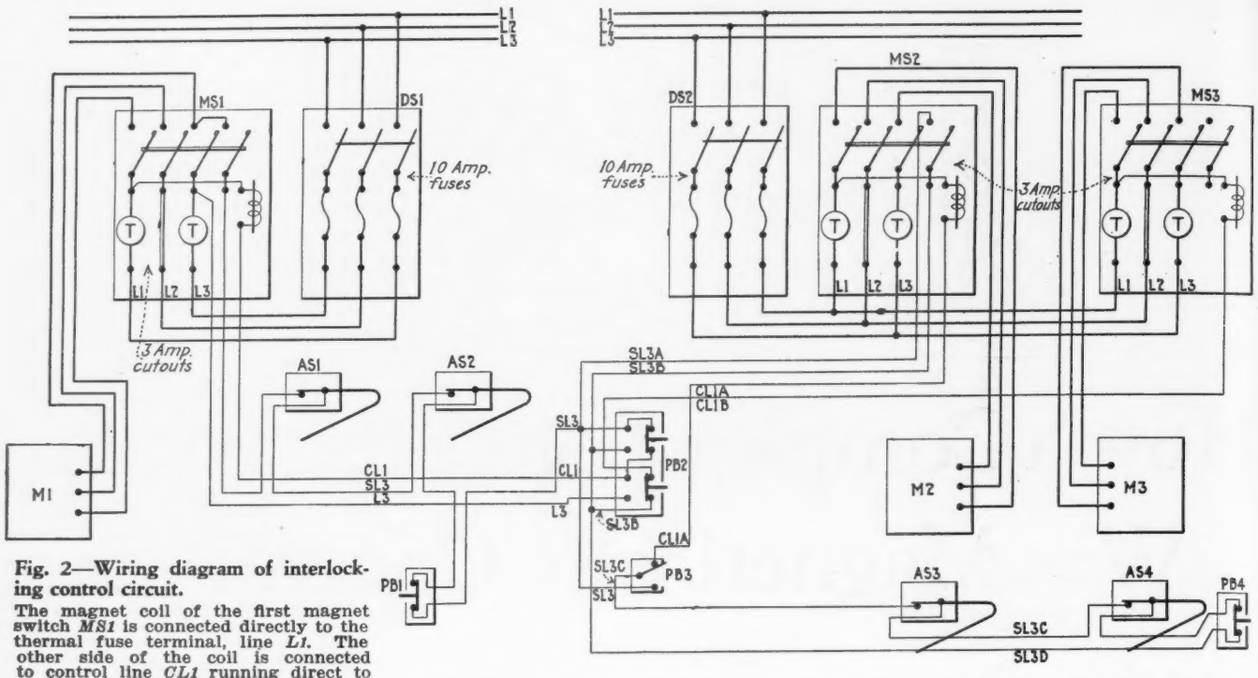


Fig. 2—Wiring diagram of interlocking control circuit.

The magnet coil of the first magnet switch *MS1* is connected directly to the thermal fuse terminal, line *L1*. The other side of the coil is connected to control line *CL1* running direct to the main pushbutton *PB2*. A second control line *SL3*, is connected to the bottom of the fourth switch blade. When the switch is closed this line is energized from power line *L3* through the thermal fuse.

vator as indicated by *PB2*. The entire system or any part of it could be started again at any time by only one man, who was responsible for the safety of all others.

In addition to the automatic limit stop switches already mentioned, additional stop buttons were provided, as indicated by *PB1* and by *PB4*. Although no push-button was provided for stopping the system at the warehouse end, this could be effected easily by merely opening the disconnect switch on partition wall, *DS1*, which shuts down the motor from this point; also the control circuit to the two other motors, yet the entire system including this motor could not be started again after this switch had been thrown in except from the start button, *PB2* at the elevator.

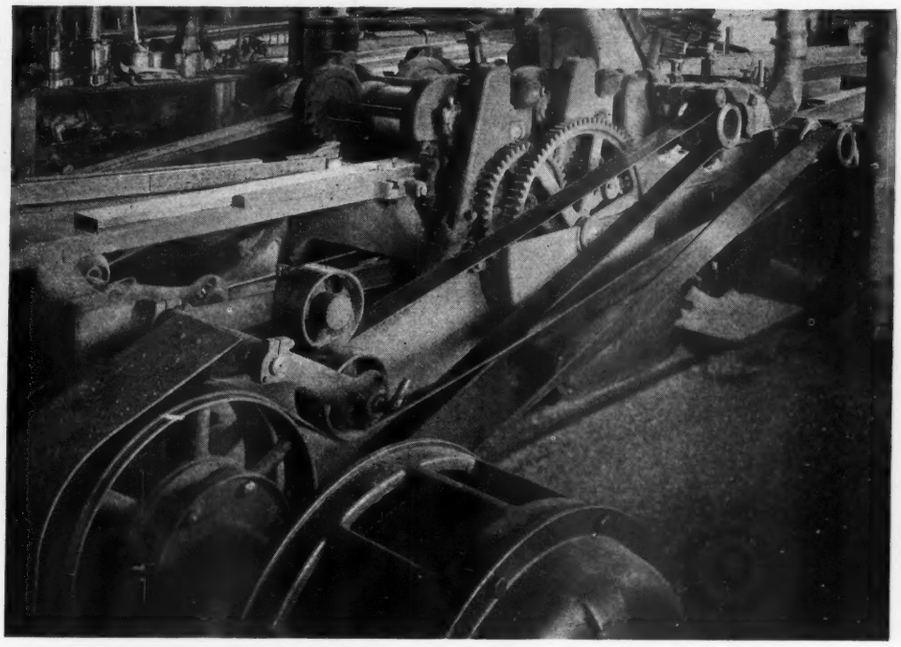
By referring to the wiring diagram Fig. 2, it will be noticed that contrary to the usual practice, the live side of the line comes into the first magnetic switch through the thermal cutout fuses, instead of through the switch blades first. This was done to break the control circuit to the other two motors and thereby stop them should this first motor become overloaded and blow out one of these thermal fuses, thereby stopping the long belt section first. Similarly, the control connections on one side of the magnet coil of the other two switches are also brought through a thermal cutout so that each motor would be stopped immediately if a thermal fuse opened the circuit from an overload, and thereby prevent the motors running single phase for even a short time.

In starting up, the start button of switch *PB2* is first depressed until it makes contact with the two inner points, the disconnect switches all being previously closed. Current from control circuit *L3*, which is always alive, passes to control line *CL1*, energizing magnet coil and switch *MS1* closes. This immediately makes control line *SL3* alive and consequently *SL3A* up to fourth switch point of *MS2*. With starting button still held in, the stop button is now pressed and this causes current from line *SL3* to flow into branch *SL3B* leading to magnet coil of switch *MS2*, through *SL3D*, *SL3C* *PB3* and *CL1A*, thereby causing this switch to close. The stop button is then released, which completes the circuit through its outer points from *SL3* to *CL1* back to coil in switch *MS1*, independent of starting line *L3*, thereby holding this switch closed as long as line *SL3* is unbroken. The start button is now released, which allows the magnet coil of switch *MS3* to be energized through the outer contact points of the button, which tie in the branch control line *CL1B* with *SL3B;* the latter having been energized from *SL3* through lines *SL3A* and *SL3B* by the closing of the fourth switch blade in *MS2*.

Turning to the safety stops, start at the beginning of the conveyor system. Opening any of the switches *AS3*, *AS4* or *PB4* would break the control circuit *SL3C* and *SL3D*, which starts from *SL3B* above the double pushbutton and ends in *PB3*, which is an ordinary key-locking type of standard two-circuit house-lighting switch. With *PB3* in position shown, which leads to magnet coil of *MS2* through line *CL1A*, current would be cut off from this coil, causing switch *MS2* to open and thereby cut off the current in branch line *SL3B*. This in turn renders magnet coil of switch *MS3* inoperative and it immediately opens, yet *MS1* has not been affected and the long belt section driven by motor *M1* would continue to operate. After the cause of stopping had been remedied motors *M2* and *M3* could again be started by going through the same procedure as outlined before in starting up the system, without stopping *M1*, providing care was taken to close the inner circuit of the start button before the stop button was pressed to start up *M2* and *M3*.

Going further along the system, should switches *AS1*, *AS2* or *PB1* be opened, the control line *SL3* would immediately be interrupted. This would stop the current to all three coils at once, through lines *CL1*, *CL1A*, and *SL3A* whose branches lead eventually to coil line *CL1B* of *MS3*. Thus *M1* driving the long belt section cannot be stopped either by the automatic limit switches or the emergency stop button without the other two motors driving the first belt and inclined elevator also stopping, thereby preventing the boxes

(Please turn to page 526)



These belts driving the cutting heads on a wood planer are operated at a speed of about 6,000 f.p.m. Note the fixed idler on the slack strand of the belt, close to the driving pulley. This idler increases the arc of contact on the small pulley and reduces the belt tension required.

Speed and Power

Their Relation in Leather Belt Drives

By ROY C. MOORE
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THIS fourth article of the series * on power transmission problems in connection with leather belt drives will begin the discussion of the operating factors concerning the leather belt itself. Previous discussions have analyzed problems arising from, and the effect of, varying center distances, the use of fixed and flexible idlers, and the effect of, pulley diameters. In these discussions the belt has been considered only as an incidental element of the drive.

One of the first questions that arises regarding the belt, and one on which there is considerable misunderstanding, is the effect of speed on its ability to transmit power. Belts, like almost every medium for the mechanical transmission of power, are confined to a certain range of speeds in which they can operate with economy and reliability. Speeds in excess of this range are often the cause of unsatisfactory operation of belts. For general factory use where the belts are of moderate widths, such as those used on general countershafting and machines, speeds between 1,000 and 3,000 f.p.m. have proven to be the most satisfactory. In the case of large main drives where the pulleys are of good size and the bearings are mounted on solid foundations, higher belt speeds, such as 5,000 to 6,000 f.p.m. have proven satisfactory.

An analysis of the maintenance records of the belts in any factory will show that small belts operating at high speeds (in excess of 3,000 f.p.m) require more attention than those operating in the range between 1,000 and 3,000 f.p.m. The better service in the lower range of belt speeds is undoubtedly because:

(1) The belts make fewer bends per minute.

(2) The pulleys remain in proper alignment for longer periods of time, as vibration at low speeds is less.

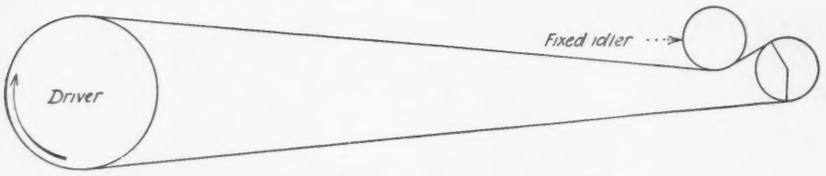
(3) The belts can correct misalignment more easily at the slower speed than at a higher speed, because they can climb the crown of the pulley.

The result is that a belt can be run at low speeds for longer intervals of time after shafts have gotten out of alignment, thereby lowering the maintenance cost. At the slower speeds, belts out of balance seldom cause trouble, but at higher speeds, particularly when they are running over small pulleys, they are likely to prove quite bothersome.

When belts are operated at very high speeds over small pulleys, the centrifugal tension plus the resistance of the belt to bending, greatly reduces the arc of contact between the belt and the pulleys. In the case of belt drives on centrifugal pumps, high-speed blowers and high-speed wood planers it will be noticed that the belt contact with the small pulleys instead of being 180 deg., as it supposedly should be, may be reduced by centrifugal force to as little as 110 deg., as is shown in an accompanying sketch.

This decrease in arc of contact can be observed on a belt that is giving trouble from this cause. To make the observation it is best to place a piece of white cardboard behind the edge of the belt and the rim of the pulley, and then sight along the pulley face, noting, while the belt is in operation, how far

*Note—The first article of this series entitled, "Factors in Determining Proper Distances for Leather Belt Drives," appeared in the May issue, the second, "Fixed and Flexible Idlers on Leather Belt Drives," in the July issue, and the third, "Influence of Pulley Diameter on Power Transmitted by Leather Belt Drives," in the August issue.



Position of fixed idler with small high-speed driven pulley.

For high-speed operation of belts when the driven pulley is the smaller a fixed idler should be placed as shown to secure the greatest wrap on the small, driven pulley. This position also serves to check the belt at the point where it runs on to the pulley, thereby securing greater pressure between belt and pulley. When the small pulley is the driving pulley a flexible idler must be used.

back the light can be observed, between the pulley face and the belt.

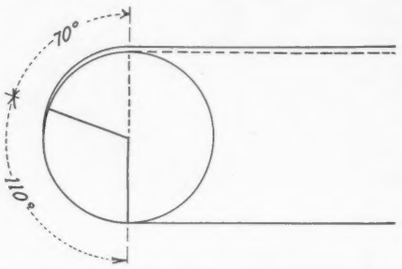
In the case of pulleys with a crowned face, the point at which the belt actually leaves the pulley is back of the place observed, but is hidden by the crown.

Wider belts, that is, 18 in. in width and over, which are generally given more careful attention, and are used on drives that are set securely on rugged foundations, seldom give trouble when operated under normal conditions at a belt speed of less than 6,000 f.p.m. Although many belts are operated in excess of this speed, it will be found that they generally require frequent attention and often are very short lived.

Some belts have been operated up to 8,000 f.p.m. In fact, it is not uncommon for the edger belts in lumber mills to operate at speeds of 7,000 to 7,500 f.p.m. In the case of several high-speed drives observed, the belt proved very troublesome, but when the speed was reduced the belt lasted much longer and gave better service. This improvement was brought about in one case by changing the 96-in. driver operating at 300 r.p.m. with a rim speed of 7,500 f.p.m. to an 82-in. pulley with a rim speed of 6,400 f.p.m. The edger pulley was reduced from 19 in. to 16 in. in diameter, which still drove the edger at 1,500 r.p.m.

The centrifugal tension in the 14-in. double (28-oz.) belt was reduced by approximately 322 lb. The 16-in. diameter pulley had about the same surface contact as the 19-in. pulley, because the slower speed allowed the belt to make a greater arc of contact on the edger pulley. The capacity of the belt was slightly higher at 6,400 f.p.m. than at 7,500 f.p.m., therefore, the belt not only operated better, but required less attention.

Belts, like almost all other mechanical equipment, have critical speeds. Very little is known about the critical speeds of belts, because it has heretofore not been a serious or general problem. It is, however, known that the critical speed is different for nearly each belt thickness of the same tannage. The critical speed of a belt is usually indicated by the belt riding from side to side on the face of the pulley or by violent flapping of the slack strand. Changing the center distance, load, or belt speed, shifts the critical point for that particular belt or drive.



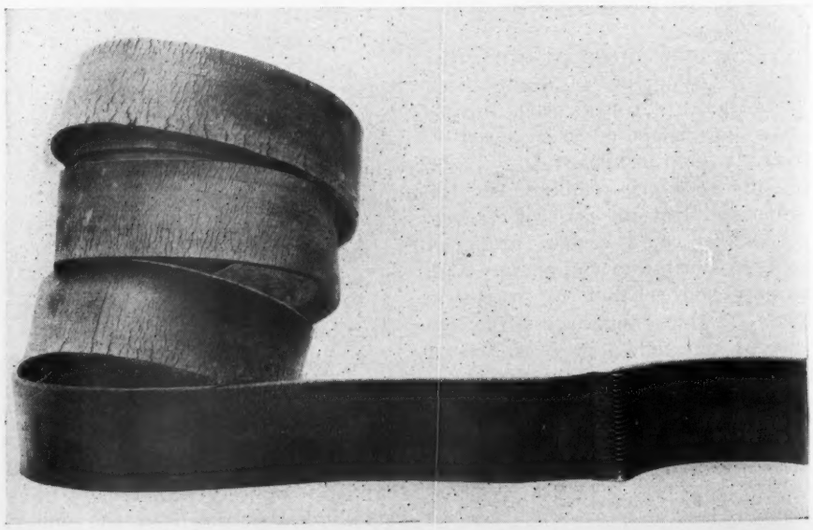
Effect of high-speed operation on arc of contact.

This sketch shows the amount of lost contact on a high-speed belt due to the centrifugal force and the resistance to bending at the high speed. This loss of contact on a belt operating around 7,000 f.p.m. under normal tension will often amount to 70 deg. as shown here, on a drive where ordinarily an arc of contact of 180 deg. would be expected. Increasing the tension to maintain contact will cause operating troubles, high maintenance cost, and short belt life. Frequently, it is possible to transmit as much power by decreasing the belt speed enough to overcome this centrifugal loss so that the full arc of contact is maintained, and at the same time increase the belt life and decrease the operating trouble and maintenance expense.

When a new belt is purchased to replace an old one, it will, if it is of a different thickness, seldom have the same period for that particular drive. Troubles of this nature have been encountered on automatic refrigerating machine drives. Under no-load or partial load the belt ran satisfactorily, but when the heaviest work was being done the belt would ride from side to side, sometimes so violently that it looked as though it would come off the pulleys.

A study of the drive showed that the motor was loaded less than 70 per cent of the time; therefore, by replacing the motor pulley with one of smaller diameter the belt speed was reduced and at the same time the peak load on the motor was also reduced, thereby incidentally cutting down the power company's demand charge. At the slower speed the belt ran satisfactorily and the motor operated approximately 80 per cent of the time.

A little care given to new, high-speed belts will add much to their life and service. When a new belt is installed on a drive where the belt speed is high, it is advisable before running to dress the belt thoroughly with a good belt dressing, preferably one of a liquid type which strikes readily into the leather. A high-speed belt should be run under no-load for some time, until the internal fibers are properly lubricated and the belt limbered up. When a load is put onto a new belt which has not been treated either by the manufacturer or after installation, the belt will be found to heat from the



Effect of high-speed operation on belts that are improperly dressed.

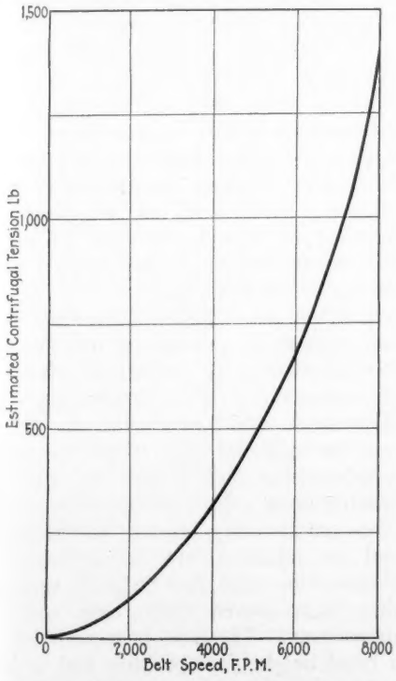
High-speed belts, such as are used on blowers and some woodworking equipment, should be well dressed when installed and permitted to run-in under light loads to limber them up. Otherwise the belts are likely to heat up because of the excess friction of the stiff belt as it slips instead of bending and hugging the pulley.

internal friction caused by the rapid bending and straightening. In some cases the heating is so great as to cause early cracking of the surface, as is shown in an accompanying illustration, and results in premature wearing out of the belt.

Drives that give trouble as a result of poor arc of contact caused by excessive belt speed and have a small driven pulley can be greatly improved by placing a fixed idler on the slack strand, as close as possible to the driven pulley. Locating the idler in this position not only increases the arc of contact on the small pulley, but through checking the motion caused by the bending of the belt around the idler, keeps the belt wrapped more tightly around the small pulley and, at the same time, permits running the belt under a lighter tension.

When the small pulley is the driving pulley a flexible idler must be used. When flexible idlers are used on high-speed drives it is advisable that they be equipped with a pulley that has been balanced dynamically at the belt speed and that the frame of the idler be equipped with checks to control the rebound.

The above suggestions are not cures for high-speed belt troubles, but will be an aid toward increasing belt life and lessening the maintenance costs. Whenever possible, it is better to avoid high speeds, thereby eliminating the cause of the troubles.



This shows the estimated centrifugal tension on a 14-in. heavy double belt at different speeds.

Socketing Wire Cable

NOT long ago an elevator in a comparatively new office building fell from the sixth floor to the basement with the result that a number of persons were injured. The investigating committee reported that the break had occurred immediately adjacent to one of the sockets, but that the tensile strength of the broken rope was amply sufficient to hold double the load of the elevator when it fell.

A mine operator had similar trouble with hoist rope some years ago. Just previous to the time the trouble developed it had been necessary to hoist an 8-ton engine to the surface. Because the age of the hoisting rope was not known a thorough inspection was given it before the task was assumed. Not a broken wire was in sight and little outside wear was visible. The engine was hoisted successfully, but three days later the rope broke with the ordinary 3-ton load. The break occurred in one of the sockets.

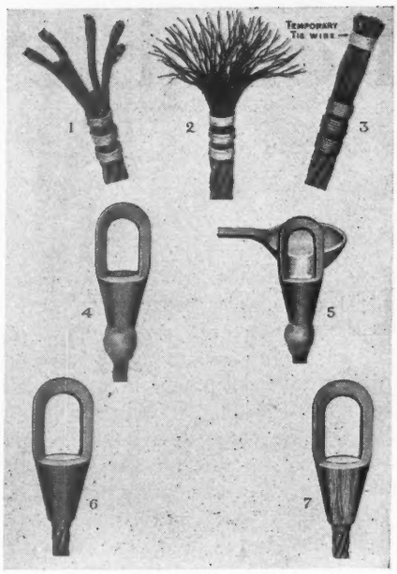
It is recommended that resocketing be done every six months, except in extreme cases when it may be needed every three months. This is necessary because, generally speaking, hoisting, shovel and dredging ropes are not accorded the maintenance to which they are entitled. Operators are inclined to inspect superficially, records are seldom kept, and resocketing is neglected. Complete replacement of a rope at stated intervals, regardless of visible condition is good practice.

In resocketing a wire rope, measure back from the end of the rope a distance equal to the length of the tapered basket of the socket. Tie securely at this point with soft, annealed iron wire and add two additional tie wires below the first.

Open up the strands and cut out the hemp core as far down toward the tie wire as possible as shown at *1* of the accompanying diagram.

Unlay each wire and straighten so as to form a "brush" as shown at *2*. On large ropes, it would be necessary to use a small pipe over each wire to straighten so as to remove most of curl from the wire. If the wire is very greasy, hold the "brush" over a pail of gasoline with the wires down and wipe off the grease with waste or a paint brush dipped in the gasoline. Wipe dry.

Dip the "brush," holding the wires point down, into a pot of muriatic acid solution composed of 50 per cent water and 50 per cent commercial acid. Insert to a depth that will *not* immerse the end of the hemp core. Keep in the acid until the wires are clean. Still holding the wires down, withdraw from the acid and knock the rope sharply with a stick (broomstick or hammer handle).



Steps in fastening a socket to the end of a wire rope.

The cable end is prepared as shown at *1*, *2*, and *3* and then inserted in the socket as shown at *4*. Melted zinc is poured over the end as shown at *5*, resulting in the finished socket shown at *6*. This illustration furnished through the courtesy of the American Cable Company.

Place a temporary tie wire, as shown at *3*, over the ends of the "brush" taking care not to handle the cleaned wires with greasy hands or tools. Then insert the rope end into the socket and cut the temporary tie wire.

Set the rope vertically in a vise with the socket placed so that the wires come flush with the top of the basket of the socket with the wires spread out. Seal the bottom of the socket with clay or asbestos as shown at *4*.

If cold, warm the socket moderately and then pour pure molten zinc (not babbitt, lead or other alloy) as in *5*. Tap the side of the socket with a light hammer while the zinc is still fluid, so as to jar the zinc into the crevices between the wires. When cool, remove the fire clay and the serving wires, and the joint shown at *6* will be the result. It will help slightly in the flowing of the zinc among the wires to put a small quantity of salammoniac crystals over the wires prior to pouring the zinc. A phantom view of the zinc cone with imbedded wires is shown at *7*.

Portable Equipment

Saves Repairmen's Time

By DONALD A. HAMPSON

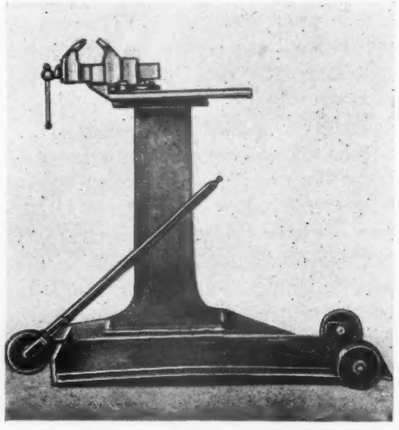
Plant Superintendent, Morgans & Wilcox Mfg. Co., Middletown, N. Y.

LACK of proper tools and facilities for doing a repair job is responsible for a large amount of the wasted time and high cost of building and equipment maintenance. One contributing factor to this waste is the fact that many repair jobs cannot be taken to the shop but must be performed out in the plant, often where tools and conveniences such as a bench and vise are not available.

The accompanying illustration shows two devices that have saved steps and hours by the hundred for the repair men in one industrial plant. One of these units is a bench vise and flat, cast-iron table top mounted on a cast-iron pedestal. The other device is an extra-low truck for transporting this vise and any other material, supplies, or equipment that may have to be moved. Except for one 4-in. Parker vise, the equipment was all made in the plant.

This factory occupies 24,000 sq.ft. of floor space on three floors, with the manufacturing machine shop and the repair department on the lower floor and other departments occupying the floors above. In the departments devoted to woodworking, pressed metal, and automatic finishing processes, no vises are provided as they are not needed for production. This causes some inconvenience on repair jobs. For example, if a machine has broken down, needs some adjustment, if some overhead work is being put up, or if a piece of electrical machinery requires a little attention, a vise is then frequently needed every few minutes and the time a man spends walking to the nearest one not only increases the cost of doing the work but also delays it. It is in such cases as this that the portable vise stand soon pays for itself. Even in other departments the repairman can carry on his work without disturbing a bench hand.

The vise stand was made up from a pedestal that the factory puts under one of its products. The table top, which is about 24 in. square was made from another standard part and was planed off on both sides. When making devices for plant use it is often possible to employ pieces which are defective or damaged and otherwise would go for scrap. The pedestal and table were bolted together and the vise was then bolted on top. The complete unit weighs nearly 200 lb., which makes it solid enough for any work required when it rests, unbolted, on the floor, but is not too heavy to drag a short distance to a more convenient working point, or to handle on and off trucks, particularly the low truck illustrated. This plant also uses several of these portable vise stands for special production work where a vise is needed only occasionally, or at some distance from the benches.



These two convenient and time-saving pieces of equipment for maintenance work have repaid their cost several times over.

The low truck is used by the maintenance department to carry repair and replacement material and supplies to the job. The bench vise mounted on the cast-iron table top and pedestal is also taken to the job on this truck. The vise saves time in that it can be placed where most convenient instead of making it necessary for the repairman to walk back and forth to a bench vise and perhaps interfere with a bench hand. Also, some departments, such as woodworking, have but few, if any, vises.

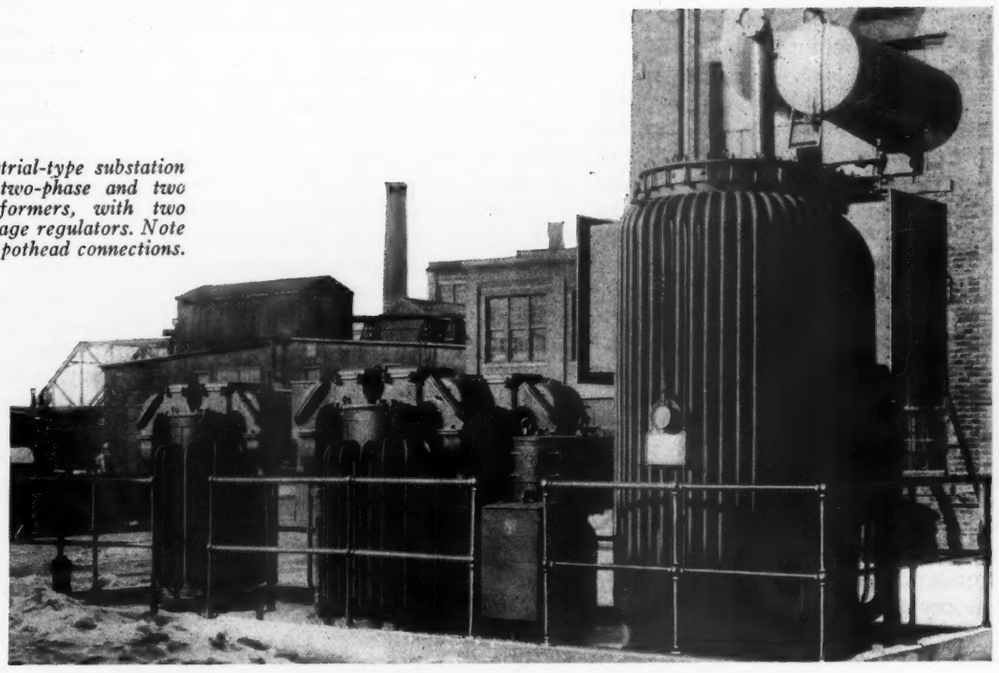
The low-platform hand truck shown in front of the vise was made especially for transporting heavy pieces of equipment about the shop. The building has good floors and so this truck could be made with only $\frac{3}{4}$-in. clearance, which made it possible to keep the total height of the platform within 2 in. of the floor. This is much lower than any of the standard factory trucks which have platforms from 12 to 30 in. above the floor.

In every industrial plant there is a certain amount of moving to be done on "floor" parts; that is, parts which are too heavy or bulky to put in stock bins and so always rest on the floor. These may be manufactured goods, portable machines or new equipment or supplies used for replacement or new installations in the drive or power transmission system in the line of production.

The repairmen's vise pedestal is a good example of this. It is too heavy for a man to pick up and carry around, no portable hoist or trolley system in this plant would take it to many of the places where it is wanted, and it would be inconvenient to put it on a standard shop truck with even the lowest platform. However, one man can tilt it and work it over upon this low platform truck.

The platform of this low truck was made from an 18-in. x 36-in. sheet of $\frac{3}{8}$-in. steel. This has been stiffened with 1-in. angles along the sides and wider pieces where the three, 4-in. x $1\frac{1}{2}$-in. wheels are. The pivoted front wheel has the handle attached to it and the men do not find it hard to move any loads that are ordinarily handled.

It does not take the experienced maintenance man long to appreciate the value of these two simple pieces of equipment. The accompanying illustration was taken when the vise was brought on the truck to the woodworking department to fit a bearing on a saw. Because these devices are so easily brought to the job and in addition are so necessary to save time and also do good work, they have saved their cost many times over. The vise is mounted at a good height for working and it is solid—two important considerations so often found lacking in many portable appliances.



This is a 2,300-volt industrial-type substation containing a 1,500-kva., two-phase and two small single-phase transformers, with two single-phase induction voltage regulators. Note the inclosed terminals and pothead connections.

Characteristics Govern Transformer Choice

By DAVID R. DALZELL

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THERE is a constantly growing tendency for industrial plants to purchase electrical energy from central stations. Inasmuch as the energy is usually supplied at high voltage, transformers are required to step down or lower the supply voltage for distribution throughout the plant.

When selecting the transformers for an industrial installation it will be advisable for the operator to obtain the benefit of the central stations' experience with this class of apparatus, in case he is not thoroughly familiar with it. In general, however, certain characteristics must be definitely established in order for the manufacturer to fill the order at minimum expense to the purchaser and in the minimum time. These characteristics are:

(1) Frequency, kva. output and voltage rating.
(2) Number of phases.
(3) Method of cooling.
(4) Electrical connections.
(5) Type of external connections.
(6) Arrangements for handling.
(7) Requirements for special applications.

The meaning and importance of these characteristics will be discussed in the following paragraphs:

Frequency——The frequency rating is always that of the supply circuit expressed in cycles per second or simply as "cycles." The commercial frequencies most commonly used are 25, 50 and 60 cycles. If frequencies other than that of the supply circuit are desired, special generating or converting apparatus will be required.

Kilovolt-ampere Output——Motors are rated in horsepower and thus have a definite relation to the kilowatts required, as 1 hp. equals approximately three-quarters of a kilowatt. Transformers, however, are rated in kilovolt-amperes, the relation of which to kilowatts is dependent upon the power factor of the load. A load composed primarily of lighting has a very high power factor, from 95 to 100 per cent, so that the kilovolt-amperes and kilowatts are practically identical. A large number of lightly-loaded induction motors on a system might cause the power factor to drop as low as 50 per cent, which would require that the transformer rating in kilovolt-amperes be double the kilowatt load, unless the power factor were improved by a synchronous condenser, synchronous motors, or by capacitors.

Modern transformers are designed in accordance with A.I.E.E. standards, and are rated in accordance with the maximum kilovolt-ampere output which they will deliver continuously without exceeding a temperature rise of 55 deg. C. (99 deg. F.) above the cooling medium. A careful study should be made of the load that the transformer is expected to supply throughout the day in order that the rating may not be exceeded by the maximum demand for any appreciable period. Future plant extension should also be considered, because it may be more economical to install, initially, transformers that will be capable of handling the ultimate load.

Voltage Rating——The high-voltage rating of the transformer will be governed by the supply voltage and may range from 460 to 33,000 volts

or in some cases, even higher. The low-voltage rating will be that required by the load. Common practice is to use 115/230-volt, single-phase, three-wire distribution for lighting, and 230, 460, 575 or 2,300 volts for the power load. It is generally desirable to supply the lighting and motor loads from separate transformer banks because of lamp flicker due to the voltage variations caused by the fluctuating motor load, and also to assure continuity of lighting service in the event of motor trouble. In large manufacturing plants it may be found economical to step down the supply voltage to some intermediate voltage such as 6,600 or 2,300 volts for further distribution to load centers throughout the plant, each of which may be provided with transformers to reduce the voltage to the proper value.

If the transformers are located near the end of a long transmission line in which there is a considerable drop in voltage, taps will be required in the high-voltage windings of the transformers so that the tap connection corresponding to the actual supply voltage may be chosen and the load voltage thus kept at the proper value. Certain voltage and kilovolt-ampere rating for distribution and step-down power transformers are being considered for adoption as standards by the National Electric Light Association, representing electrical operators, and the National Electrical Manufacturers' Association, representing the manufacturers of electrical equipment. These proposed standards for voltage ratings are given in the accompanying table. Transformers of the more commonly used ratings are kept in stock by the manufacturer and, therefore, may be obtained in a fraction of the time that would be required if special ratings were ordered.

Number of Phases —— Usually three-phase power is supplied by the central station. In such cases a three-phase transformer may be used, or three single-phase transformers may be connected to form a three-phase bank. The latter alternative is by far the more flexible, for the following reasons:

(1) Single-phase units are smaller and, therefore, easier to handle.

(2) One single-phase transformer may be kept as a spare unit for more than one three-phase bank.

(3) If a bank is delta-delta connected, one transformer may be removed and the other two units operated at reduced output, as will be shown later.

If, however, a number of separate transformer banks are involved, and especially if floor space is at a premium, three-phase units may well be used.

Transformers for two-phase operation or for effecting three-phase to two-phase transformation may be obtained in a single unit or in two separate units. In this case, also, the advantage of interchangeability will usually warrant two separate units.

Six- or twelve-phase voltages are often used to supply synchronous converters, and as floor-space is usually a determining factor in the selection of transformers for this class of service, a single unit is ordinarily used to transform from a three-phase supply.

Method of Cooling——The majority of transformers are immersed in oil, which not only increases considerably the value of the insulation on the windings, but also provides an effective cooling medium. The heat from the core and windings is carried to the tank by the oil, and dissipated from the tank surface into the air. There is practically no limit to the size of a self-cooled transformer that may be built. For indoor installation, however, particularly in the case of large units, an adequate supply of cool air of not more than 40 deg. C. (104 deg. F.) temperature is necessary.

In case it is necessary to install a transformer in a vault where a supply of air is not available, a water-cooled unit may be required. In this type the transformer is cooled by water which circulates through a copper coil placed in the oil at the top of the tank; therefore, a supply of water is necessary.

Transformers of not more than 50-kva. rating, designed for circuits of 600 volts or less, may be obtained in the air-cooled type. No oil is required as the natural air circulation will properly cool the transformer. Such units are very compact and in the smaller sizes may be mounted on a wall and provided with fittings for conduit wiring installation.

Most modern transformers are suitable for both indoor and outdoor installation. The location should be specified, however, as in the case of transformers that are installed outdoors, and for special applications requiring very heavy current, special provision may be necessary for bringing out the leads.

Electrical Connections —— There are various methods of connecting the three units of a three-phase bank. High-voltage or low-voltage windings, or both, may be connected in delta or in Y and in each case in several different ways. The accompanying

A three-phase, water-cooled, 1,550-kva., 60-cycle, 12,000/175-volt transformer with current-limiting reactors supplying a 3-ton electric steel furnace.

voltage-vector diagrams show the three different groups having different phase displacements between high- and low-voltage windings, which are marked *H* and *X* respectively. The phase displacement must be considered in the case of extensive relaying of the distribution system, but assumes major importance in the case of three-phase transformers that are to be operated in parallel with units already installed.

Parallel Operation——Transformer banks having one group of connections cannot be operated in parallel with those of another group. For example, a bank connected delta-delta, Figs. 1 and 3 in the diagram, will not operate in parallel with one connected Y-delta, as in Figs. 6 and 8. Three-phase transformers for parallel operation must be designed with the same phase displacement as that of the existing units. Single-phase transformers are more flexible, and if they have been designed for connecting in Y, any group may be obtained by the proper external connections between transformers, regardless of their polarity.

In order for a transformer to operate properly in parallel with another of the same kilovolt-ampere rating, it is also necessary that the per cent impedance voltage of each unit be approximately the same. If the impedances are different the transformer having the lower impedance will be overloaded. This also holds true in the case of three single-phase units operating in a delta-delta-connected three-phase bank, for if the impedance of one unit differs from that of the others, a balanced three-phase load will not be equally divided between them.

However, a difference in impedances may be equalized by a reactor of the proper design placed in series with a transformer having lower impedance than that of the other units in a bank.

It is also necessary that the ratio of low-voltage to high-voltage ratings be approximately the same for each transformer; otherwise current will circulate between units, thereby reducing their useful output.

On modern transformers their per cent impedance voltage as well as the voltage rating are specified on the nameplates; in the case of three-phase units, the phase displacement is indicated diagrammatically. Where new transformers are to be operated with units already installed, the complete nameplate data of the latter, including the serial number, should be given to the transformer manufacturer when placing the order.

Special Connections——When both high- and low-voltage windings in a three-phase bank are delta-connected, one of the transformers may be omitted and two units operated with the open-delta connection. This connection may prove of value where it is desired to provide transformers for an immediate load and add the third unit at some later period when the load increases. Two units operated in open delta, however, have a combined output of only 86.6 per cent of their total nameplate rating. For example, two 100-kva. single-phase transformers connected in open delta will give a bank output of only 173 kva. The addition of the third unit would increase the bank output to 300 kva. This method of operation is, therefore, not so efficient as when the full delta-delta connection is used.

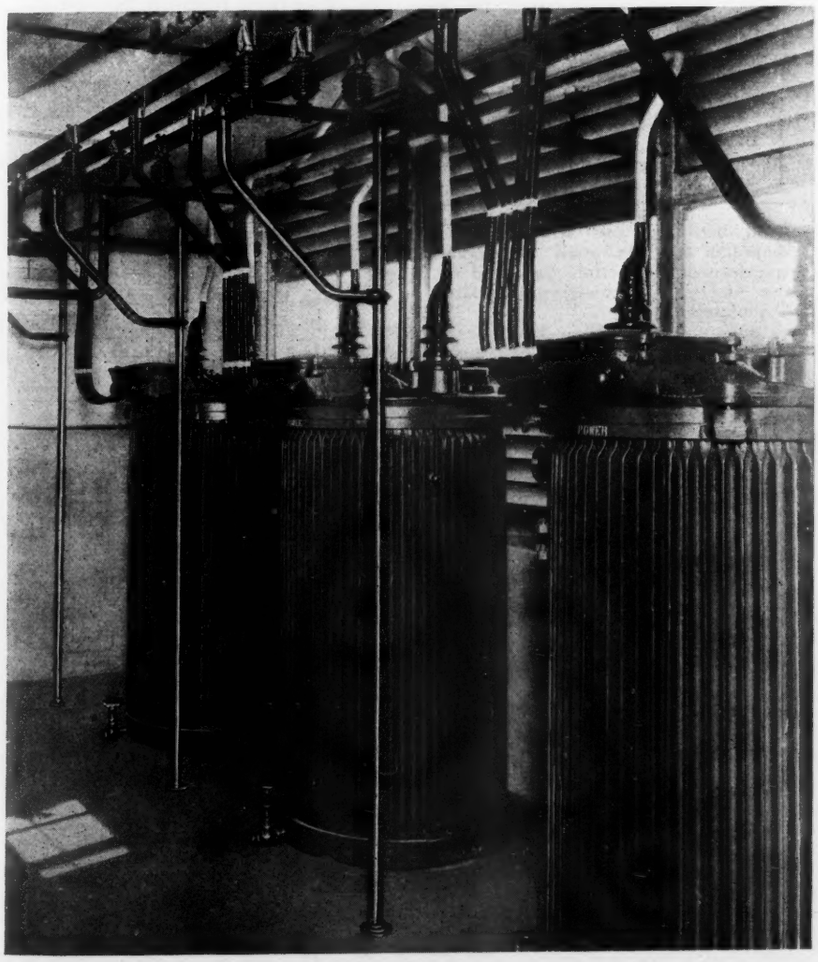
The open-delta connection will also be found useful for the emergency operation of a delta-delta-connected bank. One unit may be removed and the other two units operated at reduced capacity.

Where it is desired to transform from three phase to two phase or *vice versa,* the so-called Scott or T connection is most commonly used. This requires two transformers, a main unit having 100 per cent line voltage rating and a "teaser" unit designed for 86.6 per cent of the three-phase line voltage. The two units may be made interchangeable by providing an 86.6-per cent and a 50-per cent tap in the three-phase winding of each unit.

External Connections—— Leads are brought out from the transformer in the form of flexible cables or rigid bushings, mounted on or near the top of the transformer, that are suitable for direct connection to the buses. If desired these bushings may be completely inclosed by a steel housing with provision for conduit fitting, thereby eliminating any exposed live conductors. Similarly, potheads may be provided on the transformer, permitting direct connection to underground cables.

Both of these methods of connection find extensive application in industrial installations where it is

Ample ventilation is provided for this bank of 200-kva., 60-cycle, 13,800/230/460-volt transformers, by the louver-windows behind them.



necessary to take maximum safety precautions, or to meet Underwriters' requirements.

Arrangements for Handling—— All transformers are provided with lifting lugs for handling by cranes. Where the size warrants they are also provided with bosses for lifting by means of jacks.

If desired, large transformers may be equipped with trucks permitting the transformer to be moved in the simplest manner. The truck wheels may be either flanged or unflanged, and arranged for motion either parallel or perpendicular to a vertical plane passing through the high-voltage bushings. The track gage is best governed by the size of the transformer tank, but if desired standard or any other track gage may be supplied.

Requirements for Special Applications——The satisfactory operation of transformers can best be assured by specifying the characteristics mentioned above. For special applications, a few of which are mentioned below, detailed information regarding the nature of the service and character of the load should also be included.

Use of Auto Transformers—— Auto-transformers may be economically used instead of straight transformers, if there is no objection to an electrical connection between the two circuits, and where the low voltage is 50 per cent or more of the high voltage. As the energy actually transformed is less than that in a two-winding transformer having the same output, the cost, size and weight are considerably less. Where Underwriters' requirements permit, they may be used when both circuits have relatively low voltage, such as for supplying 115-volt lighting service from a 230-volt motor supply or *vice versa,* and as balancing coils on 115/230-volt, three-wire circuits. Auto-transformers should not be used, however, without careful consideration of their effect on the entire distribution system.

Furnace Transformers—— *The* characteristics of induction or arc furnaces are such that the transformers supplying them must have a relatively high reactance. In the case of resistance furnaces, normal reactance designs are usually satisfactory. In all cases, however, the windings must possess extremely high mechanical strength to enable them to withstand the forces caused by sudden current changes during operation of the furnace. A number of regulating taps are usually necessary for supplying a wide range of voltages to the furnace.

Transformers for Motor Loads—— As in the case of furnaces, motors that drive hoists, rolling mills or similar apparatus, are subjected to rapidly fluctuating loads, which require that the transformers supplying them possess adequate mechanical strength.

All equipment that is subjected to vibration such as encountered on electric shovels, trucks, and the like, must be designed as compactly and as sturdily as possible with ample bracing to withstand the mechanical shocks to which it will be subjected. Specially-designed transformers are available for such service.

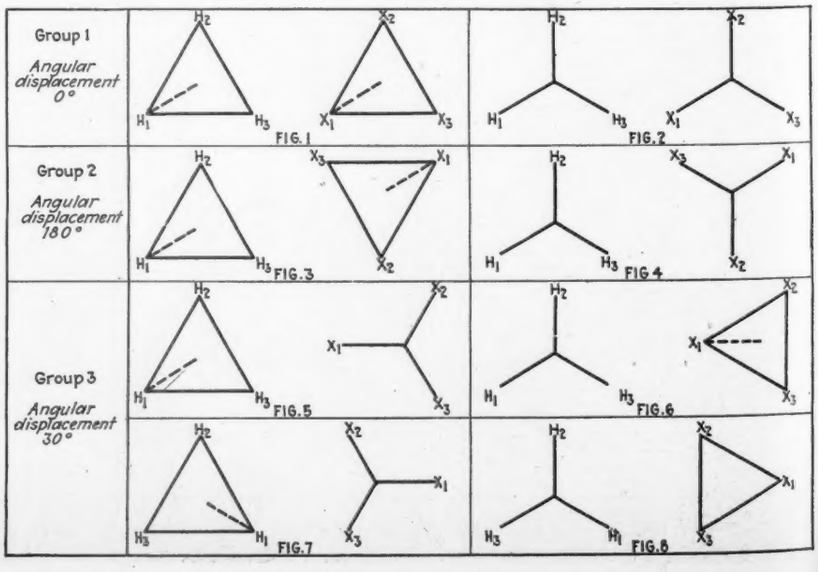
Transformers supplying synchronous converters usually must be designed for phase transformation and a certain reactance, depending upon the type of converter. Three-phase to six-phase transformation is most commonly encountered in practice. As reduced voltages are required for starting the converter, special starting taps are usually provided in the low-voltage winding. In accordance with A.I.E.E. standards, transformers for railway converters should have a nominal rating which may be exceeded by 50 per cent for 2 hr. without causing the temperature rise of the windings above the cooling medium to exceed 60 deg. C. (108 deg. F.).

Although most transformers are provided with taps for maintaining the low voltage approximately constant when the supply voltage drops below normal, the tap connections cannot be changed until the transformer is disconnected from the supply line, thereby interrupting service. In cases where it is essential or desirable that service be maintained—as in the case of electric furnaces—large transformers can be obtained which are arranged for changing the voltage connections without dropping the load. These equipments may be hand-operated or motor-operated with remote or even automatic control.

Proper installation of transformers will be discussed in a succeeding article, to appear in an early issue.

Lead markings and voltage vector diagrams for the usual three-phase transformer connections, adopted by the American Engineering Standards Committee.

In these diagrams *H* and *X* denote the high- and low-voltage sides respectively.



Methods of Increasing Grip of Open-End Wrenches

A WRENCH that has become oversized from use may not only be useless, but dangerous to anyone who uses it. In such a condition, the strain on the jaws when tightening a nut, plug or other screwed part will tend to spring the jaws farther apart.

Two methods of increasing the grip have been found to be very satisfactory. The first scheme involves the use of thin pieces of sheet iron bent to the shape of the jaw, which enables the wrench to grip the nut firmly.

If the part cannot be turned, the outside of the wrench jaws can be ground flat in order to permit a larger wrench to be placed over the first wrench, as the second scheme to use. Turning these wrenches jointly will make it possible to loosen the part with little effort. G. A. LUERS.

Washington, D. C.

Fig. 1—Continuous method of delivering loaves of bread from the coolers to the wrapping machines. This is an excellent example of the mechanical handling of commodities, and of the principle of continuity.

Floor to Floor Conveyors

By EDWARD J. TOURNIER
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THE impression in the minds of certain executives, that "speeding up" the works results in greater efficiency is due, perhaps, to a faintly perceived glimmer of the truth. It so happens that wherever mechanical handling has been substituted for muscle handling, there has been an increase in speed, followed either by greater production or by a reduction in labor cost. At the same time something else has taken place which is accepted as a matter of course, without a great amount of thought. In most cases involving a system of conveyors, the principle responsible for the improvement, is not actually the speed of the conveyors, or other apparatus; it is continuity in operations or processes, in every case, that makes possible the remarkable results obtained in all mechanicalized industries. This principle is illustrated in Fig. 1.

Transferring miscellaneous commodities from one part of a manufacturing building to another involves a number of problems, each of which may be solved by the application of suitable equipment. Also each handling operation in the plant can be carried out by some specific type of machine.

In giving consideration to this subject, it should be pointed out that the problems of industrial conveying may be broadly classified as interplant transport, interdepartment transfer and factory conveying. Each of these divisions is linked with some general type of equipment of more or less diversified design. The first is especially dependent upon company policy, while the two latter are specifically the problem of the factory executive. It is the purpose of the present discussion to show applications of different classes of conveying equipment, to factory production.

Most food products, exclusive of fresh meat and vegetables, are delivered to the consumer in some form of container or are handled during preparation, in containers. Boxes, barrels, bags, cans and the like are their most common forms. Cotton, straw, excelsior, oil cloth, are handled in the form of bales or rolls. Articles of furniture also, from beds to pianos, have been brought into the mechanical assembly line.

Various kinds of breakfast cereals which are packed in cartons are handled by a type of conveying equipment which is almost in universal use for the purpose. The small packages of shredded wheat after being filled, are placed in large cartons which are unsealed. From the packing room, the cartons pass down a roller chute and over a gravity roller conveyor to a sealing table. From this point another gravity roller conveyor carries the sealed cartons to the foot of an inclined push-bar type elevator which discharges to a storage conveyor line.

The gravity roller conveyors used in the Shredded Wheat factory at Niagara Falls, N. Y., are of two general types. The first is made up of steel tubes having ball bearing journals in each end. A through axle made of cold rolled steel carries each roller and both ends of the axles are supported on longitudinal members of the conveyor.

These members may be either a flat steel bar or an angle iron, depending on the load to be carried. The

second type consists of two parallel flat-steel or angle-iron members, each of which carries a series of rollers mounted on stud shafts or pins. The rollers are made of pressed steel and are provided with ball bearing hubs. The latter design of conveyor is generally known as a "wheel conveyor," and it is identified as such.

Handling Commodities Between Floors

The push-bar type of inclined elevator, such as the one at the shredded wheat factory consists of two strands of malleable-iron roller chain, connected at suitable intervals by pusher bars. The latter consist of cold-rolled steel rods each of which passes through a pipe sleeve that is free to revolve around the rod. The pusher bars are generally spaced 3 ft. 6 in. apart.

Usually the elevator is mounted on a structural steel frame whose essential elements are four angle-iron tracks for carrying the roller chains, and which includes supports for the transmission machinery as well as for the takeups.

However, between the upper and lower strands of chain there is a sheet steel apron extending the full width of the elevator. This apron serves as a table or slide for the commodity to be handled. When a package is placed on the loading plate at the foot of the elevator, it rests upon the apron until it receives motion from one of the push bars, and is finally delivered to the discharge point, which, in some cases, may be 40 ft. or more above the loading point in the building.

Fig. 2—Working position of the unloading fingers of a tray elevator handling miscellaneous articles in a large grocery warehouse.

The machine in the foreground is a short-section, steel-apron conveyor used to assist in rapid unloading of the tray elevator.

Push-bar elevators generally run at a chain speed of from 40 to 60 f.p.m., and are usually driven through spur gears by means of electric motors. It is desirable in this type of equipment, as well as for belt and assembly conveyors, to use inclosed speed-reduction units rather than open spur gears.

It is a requirement established by the nature of the commodities handled, that probably 90 per cent of the belt conveyors used for transporting packages or packed goods must be of the flat-belt type to insure the careful handling required.

There is more than ordinary interest attached to the three forms of package handling by means of roller conveyors, flat belt conveyors and push-bar elevators. This is because wherever quantity production of package food commodities is necessary, these three types of equipment will be found in use almost exclusively. They are practically noiseless in operation, clean and inexpensive to run.

In addition to breakfast cereals, which we have seen handled in quantity, there are a variety of other products and beverages that are being transported by similar machinery and by different combinations of the various types.

Most of the materials entering into the manufacture of clothing, from hats to shoes are most successfully handled mechanically if they are confined in some form of container or wrapper. These are usually of three classes: bales, boxes, and bags, because the contents may be then compressed into a smaller bulk, and consequently a larger quantity can be handled on a given size conveyor, than if the materials were in their natural state.

Cotton is ordinarily compressed

Fig. 3—Loading end of a wood apron conveyor handling bales of cotton from the dock to the warehouse.

The conveyor is hinged, so that it can be raised, thus clearing the floor for other uses.

into bales weighing about 500 lb. Wool and silk are generally made up in skeins packed in boxes. The manufactured forms of these products may be either rolls or bolts of cloth.

Specific Machines for Each Class of Service

Two general forms of conveying and elevating equipment are in use for handling the different classes of articles enumerated, depending upon their weight and bulk. In general, those commodities that are packed in bales and large boxes are carried on wood or steel apron conveyors and tray elevators as in Fig. 2, and all of the lighter packages such as small boxes, bags and cartons are transported on light flat belts and gravity roller conveyors. When it is necessary to elevate small articles this is done with the push-bar type of elevator previously described.

Apron conveyors, whether of wood or steel construction have been standardized as to type of chain and slats.

These conveyors consist of two parallel strands of chain connected by a series of slats each equal in width to the pitch of the chain links. This forms a continuous apron of any desired width. The slats may be either of wood or steel plates having a narrow flange at their edges. This is for adding stiffeners which an unsupported plate does not possess.

Both the upper and lower strands of chain travel on angle iron or industrial-type rails and pass over suitable sprockets at either end, or terminal, of the conveyor. One of these terminals has adjustable bearings or "takeups" to compensate for the stretch in the chain. The other, or drive end is connected through a suitable transmission to an electric motor.

A very extensive application of apron conveyors is in transferring bales from the warehouse to cars or *vice versa,* as illustrated in Fig. 3 on page 518.

Such a conveyor, 36 in. wide and 200 ft. long will handle 300 bales weighing 500 lb. each, per hour at a speed of 50 f.p.m., and requires a 7½-hp. motor for operation under maximum load conditions.

In large textile mills, where heavy rolls of cloth, or bales of cotton must be transferred from one floor to another, the tray elevator is most commonly used. This apparatus, as shown in Fig. 4, consists of two parallel strands of chain, usually of steel construction, with a series of swinging trays suspended between the chains. These trays are attached to the chains by means of swivel connections so that they always remain in a vertical position.

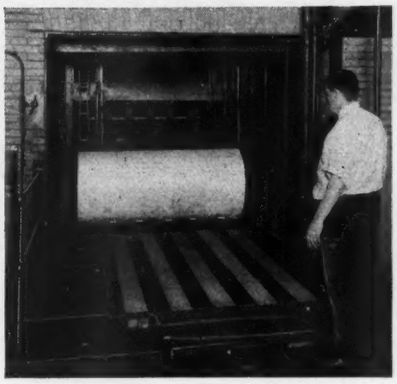

Fig. 4—Heavy-duty tray elevator delivering rolls of cloth at an intermediate floor in an oil cloth factory.
The capacity of this unit is ten, 300-lb. rolls per minute.

The head of the elevator consists of two comparatively short shafts, each carrying one of the drive sprockets and a spur gear, which leaves a clear space between sprockets, for the passage of the trays.

The transmission of power from the head shaft to the electric motor or other source, may be made through a train of spur gears or other suitable means. The introduction of a worm gear reducer between the source of power and the countershaft is desirable in order to provide against the reversal of the elevator under load, in case of the failure of power.

An elevator of this type may be designed to receive its load at the bottom, or at any intermediate floor of a building, and to discharge at the top or any point between top and bottom. It may also be made to operate in either direction, if working conditions require it.

Loading and unloading are performed automatically by means of special devices, if desired, or these functions may be carried out in part manually. The loading apparatus, which is commonly known as "loading fingers" consists of a shaft similar to that on the trays, but having the fingers set so that they will allow the tray arms to pass. The shaft which carries the loading fingers may be arranged so that by pulling a lever it is moved out of the path of the trays and the finger bars act as a stop which prevents material being loaded at that point. Another set of loading fingers at some other point is then placed in position for continuation of the work. Unloading is accomplished by means of a similar device, the operation being different from loading, only in that it takes place in the opposite direction.

Fig. 5—Combination of an apron conveyor and a modified push-bar type elevator.
This equipment is used in conveying and elevating boxes of grapes from the receiving room to the press room in a plant of the Welch Grape Juice Co.

The Factory System, New Style

The transfer of ancient household crafts to central workshops, and their transformation into factory processes by the introduction of steam power early in the last century, changed human labor from an incidental to a really continuous form. In the factories, manufacturing was still partly hand work, with the speeding up due to the new power and long hours. Here a greater degree of continuity than ever before, was obtained, with workmen servants of the machines in the line of production.

In the modern factory, Fig. 5, the ideal organization is one where the machine serves its attendents and eliminates all unnecessary labor. Although most of the operations consist of lifting or carrying, these are readily performed at great speed, without much manual effort and a good deal better by approved mechanical means.

Factory processes, as a consequence, are being grouped according to a sequence which is best served by a system of conveyors, elevators or other hoisting and transportation facilities. In all cases the aim is the introduction of the principle of continuity, which is replacing manufacturing, in the old style.

Fig. 1—General view of the manufacturing plant showing the arrangement of the heavier machinery on the lower floor, and the lighter machinery on the balconies.

Power Distribution in a Large Machine Shop

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AN ALMOST new building which was conveniently located close to the Cincinnati Milling Machine Company property was purchased and adapted to the production program established for the manufacture of the Cincinnati centerless and center-type cylindrical grinders. The type of building is well shown by the accompanying illustration, Fig. 1.

Briefly the layout of the work of the plant is such that large castings are stored and machined in the center bay which is provided with overhead traveling crane service. Also, the cylindrical grinders are tested, crated and shipped from this center bay. The main floor at each side of the center bay is used for assembling the grinders and for machining parts of medium size which can be handled by five 1-ton and two 3-ton Shepherd cranes, Fig. 2. The first balcony on the two sides contains lathes, milling machines and other machine tools for light manufacturing and tool work; a portion, however, is devoted to engineering and design work. The top balcony is largely devoted to stockrooms.

Material and parts are handled to and from the staggered loading platforms projecting from the balconies by either of two 15-ton traveling cranes with 3-ton auxiliary hoists. This layout keeps the heavier work on the main floor, and all parts progress toward the assembling, testing and shipping departments.

Before going directly into the details of the lighting system, it may be well to take up the general power distribution. Both alternating and direct current are used in the plant. The direct current is used for all variable-speed drives and the alternating current for the constant-speed drives. Three-phase, 60-cycle, alternating current is purchased from the Union Gas & Electric Co. of Cincinnati through the Factory Colony Power Co., at 13,000 volts, and it is stepped down to 110 volts for single-phase lighting and 220 volts for three-phase power use. Direct current is received at 220 volts from the same power company, which supplies direct current to a number of industrial plants in the community.

The substation is placed outside the building at one corner with the leads coming in under the walls to a seven-panel Westinghouse switchboard, Fig. 3. The d.c. power and a.c. power and light are controlled and distributed from this switchboard. The d.c. power is controlled from panel No. 1 on which is mounted two two-pole, 600-amp., fused disconnect switches, a Sangamo watt-hour meter for checking the power consumption, and two 600-amp. carbon-tip circuit breakers. The circuit breakers control the main power circuits on the east and west side of the building.

Panels Nos. 2, 3 and 4 control the three-wire 220/110-volt lighting system. The 600-amp., three-pole, oil circuit breakers for the protection of the main feeders to the east and west side of the building are mounted on panels Nos. 2 and 3. Panel No. 4 contains the main 1,200-amp. fused, dead-front disconnect switch and a recording watt-hour meter.

Panels Nos. 5, 6 and 7 control the a.c. power distribution; the main disconnect switch and recording watt-hour meter are mounted on panel No. 5, and the east and west feeder oil switches are mounted on panels Nos. 6 and 7 respectively.

The general scheme of power and light circuit location is shown in Fig. 4. One set of two 600,000 circ.mil conductors, one set of three 600,000 circ.mil and one set of three 500,000 circ.mil cables take off from the main switchboard for power and light on

the west side of the building. Because of the reduction in floor space on the east side of the building (space devoted to offices and drafting rooms) the power conductors for this side have been reduced to 500,000 circ.mil.

The physical arrangement of conduit as it takes off from the switchboard is more readily explained by the sketch, Fig. 5. All feeders, with the exception of the light circuit for the east side of the building, enter this trough-type, ceiling-mounted junction box, Fig. 5. The parallel a.c. and d.c. power lines then take off from the ends of this box and extend along the east and west sides of the building.

Special junction boxes, Fig. 6, are placed in these parallel power legs at 20-ft. intervals. Sufficient space was provided in these boxes for attaching Dossert cable taps for lines supplying the power distribution panels, Fig. 7. These are Trumbull boxes with slate barriers between the copper buses and each lead is fused with Union refillable fuses. The chief feature of these boxes is that the fuse clips are removable and readily permit the installation of fuses of larger or smaller capacities, depending upon the connected load.

The two feeder lines of three 500,000 circ.mil cables each, Fig. 4, for lighting circuits extend to distribution panels of eight and six circuits each, located on the east and west sides of the second floor, respectively. The six-circuit panel on the west side contains a north and south circuit for each of the three floors. Each of the six sub-circuits supply four of the Trumbull lighting panels. The two extra circuits on the east panel supply the two larger cabinets for the control of lights in the high center bay.

Lighting panels, which are of the Trumbull dead-front type with tumbler switches, as shown in Fig. 7, are mounted on alternate columns within convenient access to the 16 lights which they control. A plug receptacle for an extension light or small electric tool is provided just below each cabinet. In addition, Crouse-Hinds BRJ single-phase receptacle housings for BP plugs are provided at convenient locations for portable tools.

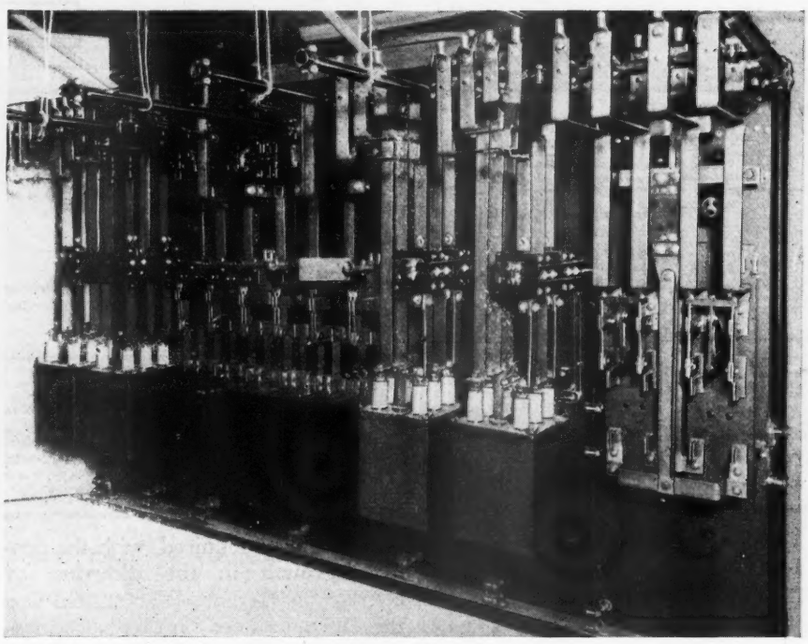


Fig. 3—Rear view of assembled seven-panel switchboard before it was connected for service.

The working space under the balconies is lighted by 200-watt lamps in Holophane reflectors spaced on 10-ft. centers. This arrangement produces an average intensity of 12 to 15 foot-candles on the working plane. The main central bay is lighted from 23 1,000-watt lamps in Holphane No. 661 reflectors mounted in the saw-tooth ceiling above the cranes. These lights are placed on 20x30-ft. centers and staggered; that is, two lights are placed in a saw tooth and one light centered in the next, and continuing with two-and-one sequence. With this arrangement an average intensity of 8 to 9 foot-candles is produced at the working plane. These intensities represent the best practice for the types of work involved.

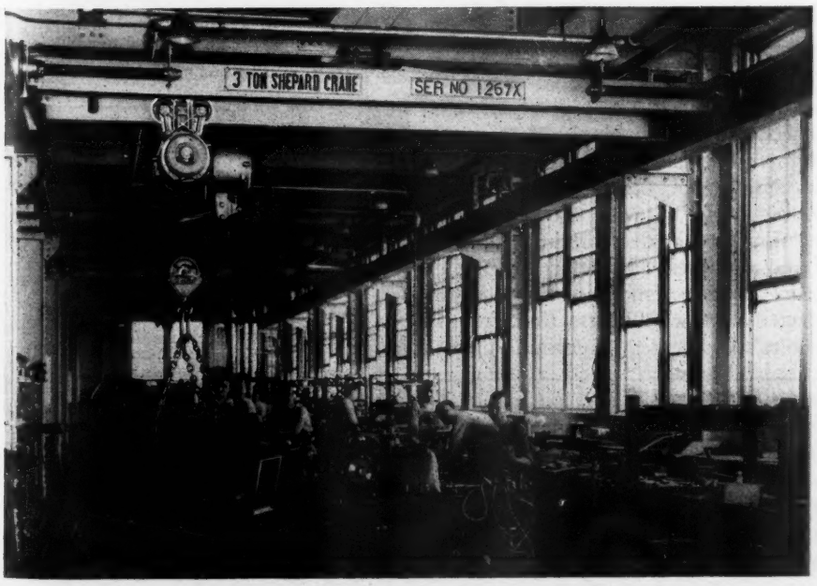
The average monthly power consumption, since the plant has been under normal production operation, has been as follows:

Power and light, a.c.	29,690 kw.-hr.
Power, a.c.	15,540 kw.-hr.
Light, a.c.	14,150 kw.-hr.
Power, d.c.	13,500 kw.-hr.

This represents approximately an average hourly load of 75 kw. for a.c. power and 65 kw. for d.c. power. The maximum combined maximum-demand rate since the plant has been in operation is 241 kw. This would leave about 101 kw. as the average

Fig. 2—A department arranged for a progressive method of assembly.

The machines progress along from one man to another as the various parts are added. This department is on the main floor under the balcony. Five 1-ton and two 3-ton Shepard floor-operated cranes, in addition to Elwell-Parker electric trucks and Stuebing hand-lift trucks, are used to handle the work.



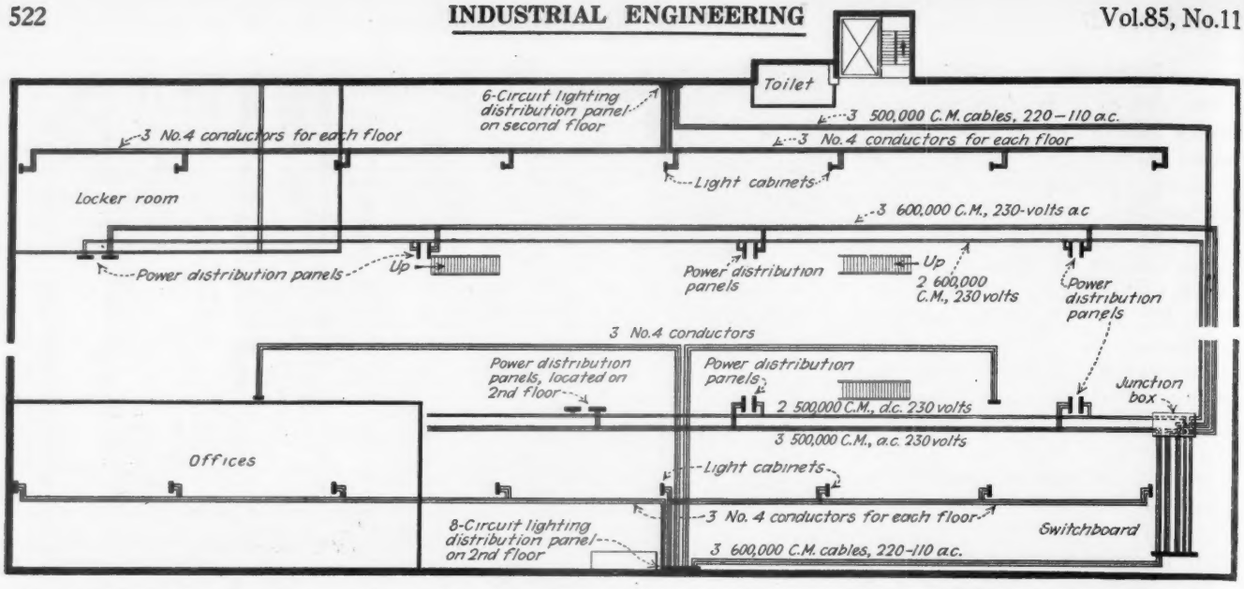
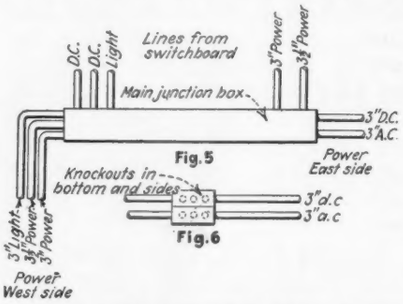


Fig. 4—Elementary line diagram of power and light circuits.

lighting load used by the entire plant.

Provision is left in all power boxes and also in the distribution line for expansion and the connection of additional equipment. The average load is but 60 per cent of the rated full-load capacity of the distribution system.

In laying out the power system the probable consumption was based on the current density rate as disclosed by the most densely machined section of the Cincinnati Milling Machine Company. If the new plant should become as densely machined there would thus be sufficient room for power expansion. This gave a density of 2.6 to 3 watts per sq.ft. of working area. Further analysis of the machines required for production indicated that an equal amount of alternating and direct current would be required, with the possible growth in the direction of alternating current. The system was therefore designed on this basis inasmuch as the exact motor requirements were unknown at that moment.



Figs. 5 and 6—Sketches of two features of the distribution system.

The upper sketch, Fig. 5, shows the arrangement of the main junction box for the distribution of power and lighting current. Three a.c. and two d.c. feeders extend from the switchboard to this box. The feeders for the east and west sides of the building are taken off from the ends of this box. This is used as a pull box and is a convenient means for eliminating fittings in a difficult place to work. Special a.c. and d.c. outlet and pull boxes, Fig. 6, lower sketch, are placed every 20 ft. for convenience.

These estimates indicated that 150 kw. of a.c. power and 150 kw. of d.c. power would probably be the maximum requirement. The feeders to the two sides were, therefore, calculated on this basis, allowing a liberal factor of safety in determining the size of the a.c. lines. In determining the sizes of lines such sections were selected that would pass the Underwriters' requirements and in addition, reduce voltage losses to a minimum.

In determining the supply mains, provision was made for future building expansion and additions. The two 800,000 circ.mil circuits on the d.c. supply lines (originally installed for the former supply system) permit of approximately 250 kw. load; therefore, sufficient expansion is allowed in this direction. The three-conductor No. 2 high-tension cable at 13,200 volts and a power factor as low as 0.75 provides for 1,550 kw.; therefore, sufficient expansion is also provided here. The transformers were likewise installed on an exchange basis, in the event of future expansion. The system is, therefore, considered to be flexible enough to take care of probable needs in the future.

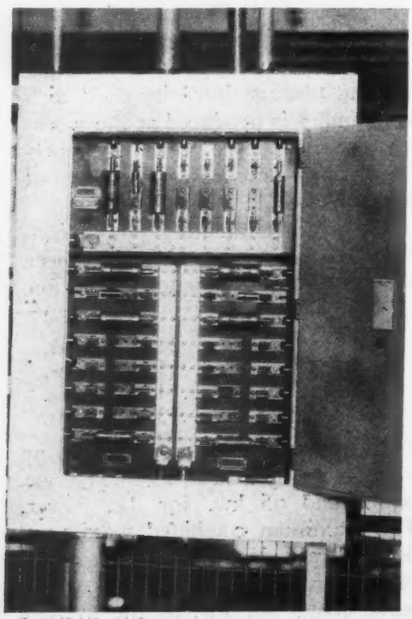
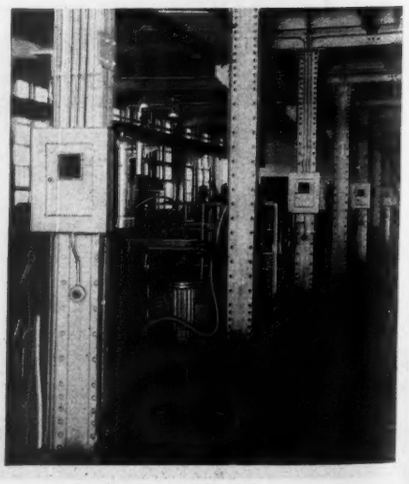


Fig. 7—One of the alternating-current power cabinets.

These Trumbull cabinets are provided with slate barriers between the copper buses to prevent flash-overs. This section of the plant is not heavily machined but sufficient provision is made in all sections so that machines can be added as desired without revamping the distribution system.

Fig. 8—General view of the lighting cabinets in the tool department.

Each cabinet is of the dead-front type with tumbler switches controlling 16 200-watt lamps in Holophone reflectors, mounted on 10-ft. centers. A plug receptacle for an extension cord or small portable tool is placed beneath each cabinet. This department is completely equipped with individually driven Cincinnati plain and universal milling machines.



Long-Time Guarantees of Prosperity

By EDWARD J. MEHREN
Vice-President,
McGraw-Hill Publishing Co., Inc.,
New York, N. Y.

I HAVE elected to speak today on prosperity. It is one of our most active topics. Can we maintain it? Can we go to ever higher levels? Or have we reached the top and must we soon retire to less active business and a lower standard of living?

There are obviously many factors in making prosperity, and if exact definition be insisted upon, one must admit that there can be no absolute guarantee of unbroken high-speed business. But there are certain fundamental factors so deep and broad in their influence that there seems no better synonym than the word I have used.

America's Production

To begin with, let us get a picture of America's recent industrial development. The last U. S. census of manufactures showed that the volume of our manufactured goods in 1925 was 2¾ times that of 1899, but that the number of men employed was only 1.8 times as great. In other words, there has been a great increase in output per worker; in fact, each man now produces 50 per cent more than he did in 1899. The reason is that we now use 3½ times as much power as we did 28 years ago. We have transferred the work of industry from the backs of men to the inanimate forces of steam and electricity.

As a result of the use of power and machinery, therefore, 67 men now do as much work as 100 men did before.

Where have gone these men thrown off as surplus labor by the older industries? The answer is that they have gone into new industries and are making products undreamed of in 1899. That important phenomenon is at the bottom of our prosperity.

In this absorptive power, in this receptive power, lies the fundamental secret of American prosperity. We have a market of extraordinary receptivity and adaptability. To us that no longer seems remarkable. We live with it. It seems as though it could not be otherwise. But it is extraordinary, truly a wonder. For contrast, look at the Old World, with its lower level of receptivity and its inevitably lower standard of living. So did their father; so will they do. As a result, while the European merchant fights feverishly for foreign trade, a market of tremendous potentiality—the home market—lies undeveloped at his very feet.

Edward J. Mehren

Developing Receptivity

The first long-time guarantee, then, of prosperity is the preservation of this adaptability and receptivity of the American people. The primary means of preserving it is to continue to raise the level of intelligence of our people, and this demands a continuance of liberal support of our educational system. A second means of preserving this receptivity is to give the public an opportunity to exercise this faculty. If they never have anything new, they will be content with the old. We must expect, yes, we must foster, a continuous increase in the purchasing power of both the salaried and wage groups.

Here, then, we find a market of remarkable receptivity. It is obvious that we must supply it with more staples and particularly with new goods. Design of present goods must constantly be improved, but that is not sufficient. We must go behind the design room; we must go to the research laboratory, where radically new products and processes are discovered. *There* we will find, rather than in the design room, another long-time guarantee of prosperity.

I make no apology for pleading with you, bankers, industrialists, merchants, for bounteous support of research. You are building for the future. It is your hope that the businesses you are rearing will pass in vigor to your business heirs. I hold out to you a promise: future industrial success—if you employ research, and I hold out a threat: industrial lameness and decay, if you neglect it.

Purchasing Power

So now we have two long-time guarantees of prosperity: First, the maintenance of a receptive market, and, second, research for the creation of new products. Then what? Obviously, the receptive market must be able to buy the new products as well as more of the old. That brings us to the question of purchasing power.

It should be evident that if we merely maintain our present purchasing power we cannot take new goods in addition to the old we are absorbing today. It is absolutely necessary, therefore, that the public's purchasing power must constantly grow larger. The old grumbling against an apparently too prosperous salary and wage group must give way to the appreciation that well-paid workers are good customers, and that good customers keep the factory wheels moving. Aye, more, a halt in the increase in purchasing power will bring industrial distress, for it would then be impossible to absorb into new industries the men released from the old.

There are two ways of increasing purchasing power: First, by reducing prices so that the present salary and wage dollar will buy more goods, and, second, by increasing the number of salary and wage dollars. We are using both methods in this coun-

Abstract of an address before the Chicago Association of Commerce, Oct. 19, 1927.

try. Improvement in management, elimination of production wastes, simplification of varieties in all manner of products, standardization of materials and parts and last, but not least, research—all these are mechanisms that we are applying, and that lead to lower production costs, lower selling prices and constantly higher purchasing power of the dollar.

In addition, we have increased the number of salary and wage dollars faster than the increase in the cost of living. More and more we are abandoning the theory of the "living-wage." We believe in something more liberal, in what I call a "security wage," a wage that provides not merely a decent living, but enough margin to own a home, to educate the family, and lay up savings that will secure the worker against the fears of unemployment, sickness and old age. To make such provision for himself and his family is the natural ambition of every healthy-minded man. To be content with less is to reduce one's self to a definitely inferior social order. To be content with less is to accept dependence rather than freedom, and freedom, economic as well as political, is the proper ideal of every American.

An additional, large advantage of having well-paid salary and wage earners, is the industrial co-operation that results. Well-paid workers, under wise leadership are ambitious, saving and contented, and help reduce production costs. The combination of such workers, fair-minded capital and efficient management, make an impregnable industrial system.

Flow of Goods to Market

The next step after increasing purchasing power is to provide for the economical flow of goods from the manufacturer to the public. Manufacturing economy requires mass production, and mass production requires mass distribution. Here we come back to research. The area for the recovery of wastes in distribution is possibly larger today than in production, but it will yield economies only by experiment, study and research. The field is tremendous and again I plead for your generous support of research, this time of research in distribution. Further, I would let modesty and restraint do you an injustice did I not point out the need for still wider understanding of that "sword arm of business," advertising, which creates wants and mass demands, and is the channel through which knowledge of new products becomes known to the buying public.

The Circle

We have then, this recurring sequence: we use continually more power and machinery, and as a result increase the output per worker. This, in turn, has two effects: first, it increases the workers' earnings, and, second, because fewer men are needed throws off a surplus of labor. This surplus must, then, find employment in new industries whose product will be bought by the workers whose earnings have been increased. The crux of the situation, then, is to continue to increase the output per worker and to find new products to absorb the surplus labor thrown off by the older industries.

The process obviously proceeds in a circle, but in an ever widening one. We increase output and earnings per worker and create a labor surplus. This surplus is absorbed by making new products which are then sold to the workers whose purchasing power has been increased.

Naturally, there are other factors that affect our prosperity. I have mentioned two of them—the receptivity of our people and the effective use of advertising as a means of creating demands. There are many others. Their discussion in a short address would be confusing, even if possible. Those I have chosen, though, are fundamental. Their understanding will go far to keep up a general upward trend, even though from time to time there may be recessions, even as the one we seem to be going into just now. I hold out no panacea, no guarantee against occasional recessions. My subject was deliberately chosen as the long-time guarantees, and the fundamentals I have developed seem to me to deserve such description.

Fortunately we have a number of agencies that are helping and that supplement individual and corporate effort. They will go far to safeguard us if we know how to use them. I refer, first, to the trade association; second, to government departments; third, to the universities; and, fourth, to the business press. Of the trade association I need hardly speak. Its service in fostering sound trade practice, encouraging research and carrying on joint propaganda are of the very marrow of American business. It forms an excellent agency for joint research when one group of laboratories can serve all, or when individual businesses are not "sold" on separate research activities. Of the government departments, let me recall the service of the Bureau of Standards and the Bureau of Mines, and particularly of those newer bureaus developed under that extraordinary business statesman, the present Secretary of Commerce.

The universities make a contribution all too little appreciated. The industry that lacks contact with the university today is doing itself an injustice. There they have in the making the business men of tomorrow, your successors. There they have a fine enthusiasm for research—typified in a splendid way by the Engineering Experiment Station of your own State University—the University of Illinois—which, I am proud to say, is my own Alma Mater. They are studying distribution with the advantage of detachment from the drive and the detail, and are trying to deduce laws that will help you and me.

There is finally the business press, which is business articulate, the instrument for welding all phases and branches of each industry or trade into a harmonious, homogeneous whole. It is an agency for interpreting business, its trends and problems, to business itself and other groups of the community. It is a medium for exchanging ideas on these vital problems I have discussed, cost reduction and research, and finally, it is the chosen instrument for clarifying, crystallizing and expressing the ideals and objectives of industry and trade.

Conclusion

If, then, the discussion we have gone through together be sound, it is the responsibility of every American business executive to give generous support to cost reduction efforts and to industrial and scientific research. They must have faith in the receptivity of the American people and a knowledge of the use of advertising to take advantage of that receptivity. Above all they must support research in their own corporations, in trade associations and in the universities. We will most certainly continue to increase our industrial capacity. If we fail to discover new products at a rate sufficient to absorb surplus labor we shall have to divide the fruits of industry between a larger number of workers, our purchasing power will decline and our standards of living drop to lower levels. If we can find new products at a sufficient rate we shall be able to absorb the surplus labor and continue our upward march.

Prevention of High-Voltage Hazards in Industrial Sub-Stations

By WALTER C. WAGNER

The Philadelphia Electric Co., Philadelphia, Pa.

WITH THE increasing tendency of industrial plants toward purchase of high-voltage power a new safety problem is brought into the plant. In many cases the plant operators are familiar only with the more common low voltages and need advice on the safety features necessary in operating the high-voltage equipment. The following is an abstract of some of the more important points, as seen by the supplier of the power, from a paper delivered before the sixteenth annual safety congress, which was held at the Stevens Hotel, Chicago, Sept. 26 to 30.

The necessity of low first costs and operating expenses requires the absolute minimum of installation, operation and maintenance costs, compatible with the safeguarding of man and maintaining the proper degree of service continuity. The paper briefly reviews some present problems, indicates progress of a few recent developments, and outlines the trend of rules and regulations upon which to depend for guidance. The problems may, in general, be divided into groups, according to the development of the works.

Studies of Design Layout

In the preliminary study and design period, joint effort is often required to secure proper housing conditions for substation receiving equipment and conductors. The industrial man responsible must actively join with the representatives of the supplier in studies of physical conditions, the analysis of the customer's operating requirements, and contribute in matters such as those relating to exposures, ventilation, illumination, accessibility, guarding and clearances.

It has been found good practice to require the signature of the safety engineer on all design drawings before they go into effect. This assures greater uniformity in design, and provisions for changes due to new conditions arising, such as, protection from fire streams, blanking off ventilation or exits, or other obstructions, loss of illumination, inadequate grounding, or the proximity of unnecessary amounts of combustible materials.

It is in the design period that maintenance features must be incorporated, these varying with operating conditions. Will operating conditions permit killing of all service lines and equipment, or must additional clearances, isolation or guarding be considered? Where continuity of service is paramount, the alternative of the spare unit must be balanced against other methods which will insure adequate protection to the customer's and company's maintenance men, assure continuity of service, and minimize the duration of interruptions.

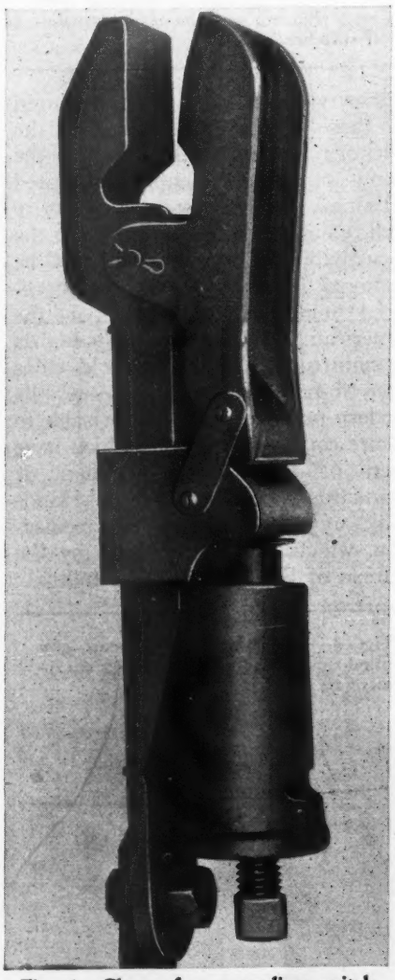


Fig. 1—Clamp for grounding switch terminals in 13.2 kv. oil switch truck.

To operate this grounding clamp place handle (above) in socket to engage ¾-in. bolt. Turn the handle to the right and the bolt forces the wedge against the movable clamp, thus closing the jaws. To release the clamp, turn the handle to the left.

Safety equipment is necessary. It has been the practice of some electric power companies to furnish, among other articles, a pair of rubber gloves, and later to inspect and maintain them. Experience has shown that the reliability of rubber gloves cannot always be determined by handling or visible inspection. It is advisable to request the customer to purchase and install rubber gloves initially, to maintain them, and to have them tested at frequent intervals.

An improvement of design of switching apparatus for the more important customers is found in the development of the truck-type switch. These trucks have complete enclosures of light sheet steel, whose switch mechanism, together with related equipment and wiring, is killed by withdrawing the carrying truck from the enclosure.

Safety in Construction

A solution of the problem of providing a proper grounding clamp to ground the switch terminals in the enclosure is shown in Fig. 1. Problems still remain concerning the best method of installing and isolating potential transformers and of gaining quick access to switch parts.

Indicators for the position of all high-tension oil switches have been slowly developed. One company uses the terms "open" and "closed" for its markings, Fig. 2, but recently an interruption to service was prolonged because a new man, an old steam engineer, thought that the word "open" as applied to the case of a steam valve, meant a flow of energy, and "closed," an interruption of the flow. Manufacturers quite generally use the terms "off" and "on." The method

of grounding, consistent with the larger use and greater importance of power supply, is, in general, to have multiple grounds connected by sweating to the common substantial copper ground bus at different points. In some instances even lightning arrester grounds are now being connected to the common grounding network at very large industrial substations in order to reduce the ground resistance to the minimum, but this should not be done where a hazardous rise in potential may develop.

During the construction period, neglect to insist on the removal of all but the minimum possible amount of combustible material has caused serious fires. It has been found advisable, at times, to require an extra extinguisher, particularly during temporary construction periods.

Maintenance and Operation

From the operating standpoint, company responsibilities actively begin with the introduction of current. Every effort should be used in aiding the customer, such as making personal contacts with the prospective operator of the substation, and the installing of glass-covered or varnished-surface single line circuit diagrams and operating rules. First-aid prone-pressure resuscitation must be discussed, and if practicable, a lesson given to the men in the presence of their employer. With the employer interested, a labor turnover is less likely to lead to a loss of these instructions by the new men. The practice of making use of every electric utility employee visitor to the customer's substation, such as the meter reader, the meter tester, and the maintenance man, to advise of any unsafe conditions is to be commended.

In testing equipment to determine whether it is alive, no maintenance work should be allowed until a double check on the dead circuit is made. The neon gas-filled tube at the end of a switch hook, Fig. 3, has been extensively used but the necessity of opening a compartment for accessibility to a known live part, in checking the integrity of the tube, is an unnecessary hazard. One company is now installing a Ford coil by which this tube can be safely lighted before and after the test of the supposed dead section, thus making certain that the tube has been operative during the test. A metal switch-hook terminal with condenser has also been used to advantage, utilizing the spark discharge as an indication.

It is of course necessary to be an authority on all safety rules required by those having jurisdiction in the territory served, and to know the trend of developments in related activities. Many state regulatory bodies and others are waiting for the formal approval of the revision of the National Electrical Safety Code revised under the auspices of the American Engineering Standards Committee. Many of the old rules have been changed to meet the modern practice, and it is advisable to secure copies of the rules which have been printed by the Bureau of Standards, Washington, D. C. Handbooks of most interest in this connection, which have been issued by the Bureau of Standards, are as follows: Handbook No. 6—"Safety Rules for the Installation and Maintenance of Electrical Supply Stations"; No. 7—"Safety Rules for the Installation and Maintenance of Electric Utilization Equipment;" No. 8—"Safety Rules for the Operation of Electrical Equipment and Lines"; No. 10—"Safety Rules for the Installation and Maintenance of Electrical Supply and Communication Lines." It is recommended, in the absence of other rules or in the face of existing local rules, that operators urge the adoption of these revised National Rules.

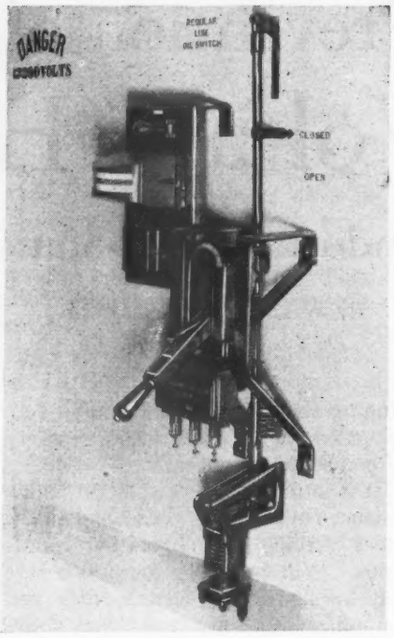
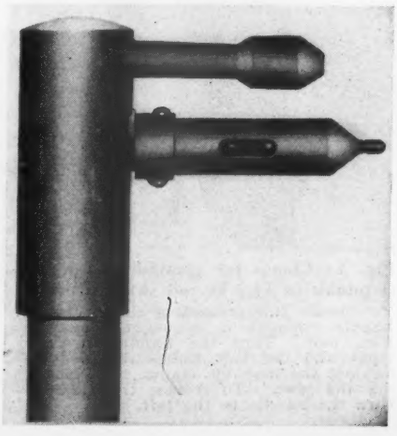


Fig. 2—One method of marking indicators showing position of high-tension oil switches.

Fig. 3—Switch-hook with neon gas-filled tube at the end for testing equipment to see if it is alive.



Complex Conveyor System

(*Continued from page 508*)

from being fed onto the belt when not moving. It is obvious that depressing the stop button of *PB2* at any time would disconnect control line *CL1* from *SL3,* thereby causing switch *MS1* to open and this in turn would break the circuit of *SL3* to the other two switch magnet coils, opening those switches in almost the same instant.

As to the use of the switch *PB3,* which was another addition of necessity, this was installed to permit operation of the two belt conveyors without the elevator. To start up only the two belts, it merely required pressing the start button of *PB2* to close switch *MS1* and upon releasing this button *MS3* would immediately follow. Although it was impossible to accidently start up the elevator motor *M2* with *PB3* in this position, a rule was established to always remove the thermal plug fuses of the motor on any unit being repaired as an extra safety precaution.

The switches used in this installation were all standard and no changes had to be made except in the methods of connecting up the fuses and contact points. The magnetic switches are G. E. Co., type *CR 7005-D4* with thermal plugs of the proper rating for each motor, using fusible link cat. No. 167539. The main stop and start pushbutton station is also a G. E. product; Cat. No. *BS212-A,* as well as *PB1* and *PB4,* which are of the momentary contact class but with circuit normally closed. Limit switches *AS1* to *AS4* are of Cutler-Hammer make, with the usual roller wheel replaced by an extension arm with a reverse bend as shown. Although these were a two-pole type of switch, it was only necessary to use but one side of each.

Types and Functions of OVERLOAD RELAYS

By H. D. JAMES
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PREVIOUS articles in this series on control equipment which have already appeared in INDUSTRIAL ENGINEERING, have discussed the importance of application, functions of operation and the considerations that influence the design of arc-rupturing devices. Another point, however, of equal importance, is that of the selection of the relay devices that provide protection to the motor.

The requirements for overload protection of electric motors may be divided into two groups:

(1) Protection against accidental conditions of the circuit such as a short circuit, ground or some very abnormal operating condition. Protection against this type of overload is usually afforded by the same device that protects the feeder supplying power to the motor. These feeders are usually protected by an approved fuse which is capable of rupturing abnormal overloads as well as being of a suitable size to protect the feeders from overheating with normal overloads. The size of the fuse suitable for each size of feeder is given in the National Electric Code issued by the National Fire Protection Association.

Large feeders may be protected by circuit breakers instead of fuses. The National Electric Code gives all of the detail information necessary for selecting such overload protection and need not be discussed in detail in this article.

(2) Protection against normal operating overloads. A motor may be overloaded sufficient to cause overheating and a rapid aging of its insulation without taking enough current from the line to open the feeder protection. The motor has considerable thermal capacity so that short-time overloads may not cause undue heating. The same is true of control apparatus and other equipment connected in the motor circuit. The kind of protection required for the motor depends a great deal upon the application. The simplest problem consists in protecting motors operating on a continuous load. If the motor is applied to an intermittent load it is usually for short periods of time which are limited by the process of application and, therefore, we are only interested in keeping these peaks within definite limits assuming that if this is done the motor will not be dangerously heated.

Coil and Plunger Relays—The controller has a circuit closing device which may be a magnetic contactor or a manual switch held in the closed position by a low-voltage magnet. In the event of a continuing overload, a relay opens the circuit to the coil of the contactor or low-voltage magnet and disconnects the motor from the source of power.

The most common form of relay has been an electromagnet of the coil and plunger type provided with an oil dashpot which introduces a time element so that the relay would not open its contacts during the starting period of the motor or on very short time overloads. The tripping value of the relay can be adjusted by changing the air gap in the open position of the plunger. The calibration is expressed in amperes and some means provided for locking the adjustment when made. Wider ranges of adjustment are made by changing the series winding or relay coil. Relays of this type are illustrated in Figs. 1 and 2 on page 528. They are generally well understood and the descriptions under the illustrations seem sufficient.

During the last year or two, the practice of starting squirrel-cage induction motors by connecting them to the full voltage of the circuit has changed from a maximum of 5 hp. to 50 hp. and larger in some cases. The 5-hp. motor accelerated to full speed in a very few seconds, so that a fuse or dashpot type of relay was reasonably successful for such applications. Larger motors require more time to accelerate and consequently introduce a new problem in overload protection. When these larger motors were started on reduced voltage the relay was inoperative during the starting period; when the motor was transferred from reduced voltage to full voltage the relay became operative but the overload during transfer was of such short duration that the dashpot relay or even fuses proved satisfactory. If the controller provides a starting and running position the relays can be connected so that they are not in circuit during the starting period even though the starting may be at full voltage, but this additional point seems unnecessary for full-voltage starting and is only used when a suitable relay is not available.

In order to meet this new demand for overload protection a new form of relay was developed commonly called the thermal relay. The usual form of this relay particularly for the smaller motors consists in the thermal responsive element and a heater, whose temperature is directly proportionate to the current. This heater may be a small resistor in series with a motor, or a heater may be used for a.c. circuits which depends on the induction in the iron of

This is the fourth article of a series in which Mr. James is discussing the functions of control equipment in the operation of motor drives, and describing the construction and operating principles of the types of such equipment in industrial use. The first article which appeared in the March issue dealt with the general application of control equipment. The second article in the May issue covered the functions of control. The third article in the September number described arc-rupturing devices. The fifth article of this series will appear in an early issue.

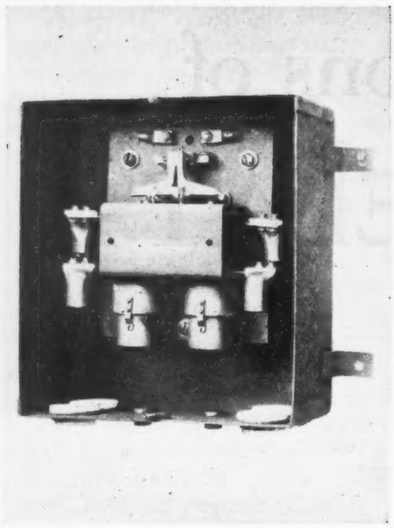


Fig. 1--Overload relay of the coil and plunger type.
This *KN* relay shown is for use with polyphase motors and it has two overload elements operating a single contact. Its operation is the same as the *AB* relay in Fig. 2.

a magnetic circuit. A number of illustrations, therefore, are shown of different commercial designs.

These relays, therefore, may be divided into two classes dependent on the type of heat responsive means used. They are: *(1)* BIMETAL RELAYS and *(2)* FUSIBLE ALLOY RELAYS.

Bimetal is a name given to a metal strip or sheet made by rolling together two dissimilar metals having a considerable difference in their temperature coefficients. If a strip of this material is heated it will bend due to one metal expanding more rapidly than the other. Relays of this type make use of the bending or deflecting of a bimetal strip to open or close a contact. For motor protection the contact is usually opened. The motor current may be passed through the bimetal strip and heated directly or the heat may be transferred to the bimetal strip from a resistor in series with the motor. Manufacturing difficulties result if current is passed through the bimetal strip as this requires a different cross-section of bimetal for every ampere rating. It is better practice to make the bimetal of the same section and arrange the rating of the relay by making different heater elements. Each relay is usually provided with means for adjusting its tripping point, over a limited range. An adjustment from 80 to 120 per cent of the heater rating is quite common.

The bimetal strip deflects slowly under the influence of heat. This may cause bad action on the relay contacts so that most relays are designed to provide for a quick make and break of the contact or take care of this condition in some other way. The different methods are stated under each illustration and a brief description follows.

The overload elements of the type *TC-221* relay shown in Fig. 3 consists of two parts:

(1) A heater coil enclosed in a cast shell which gives the relay increased thermal capacity. This heat is communicated to a bimetal element which deflects and opens the relay contacts.

(2) The bimetal element which is in shunt to the heater coil passes a small part of the motor current directly through this element, which contributes to the heating of the bimetal strip but under ordinary load conditions is not sufficient to open the contacts. If a short circuit occurs the current through the bimetal strip will be sufficient to open the relay contacts before the heater coil is injured. This relay can be obtained both single-pole and double-pole and can be given sufficient thermal capacity so that it has the same time temperature curve as the motor with which it is used.

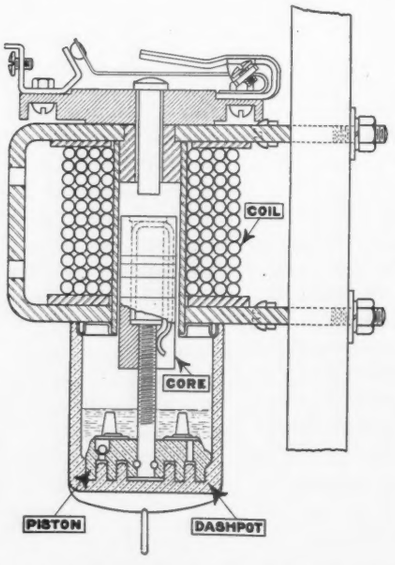


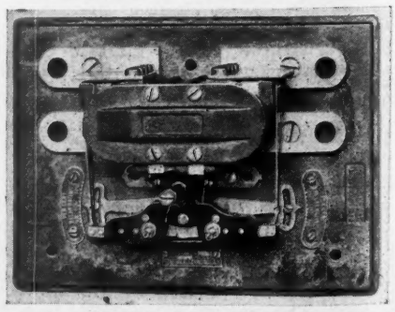
Fig. 2—Cross-section view of coil and plunger-type, overload relay.
The time element in this *AB* relay is obtained by an oil dashpot, which retards the tripping of the relay. It is arranged with a valve to permit quick resetting. Fine adjustments are obtained by raising or lowering the plunger in its open position.

Two heater elements are used in the type *TC-121-C* relay shown in Fig. 4, one connected in each of two leads. A strip of thermostatic metal is mounted directly above each heater, also a contact mechanism which is held closed by the thermostatic strip when in the normal position. When the motor is overloaded, the heat from the heater unit causes the thermostatic strip to deflect to such an extent as to allow the contact mechanism to trip and disconnect the motor from the line. The rating of the relay is in amperes and is changed by changing the heater elements. An adjustment is provided for each element of the relay so that the latch will trip from 80 to 120 per cent of the heater rating.

In the *Thermaload* relay, which is illustrated in Fig. 5, the overload element consists of a bimetal strip wound in the form of a spiral, the lower end of which is anchored. The upper end is free to move. On overload the upper end of the spiral lifts the arm of the relay, located between the two spirals, sufficiently to separate the relay contacts. By referring to the line diagram in Fig. 6, it will be seen that two contacts are used, the one that opens first is in series with the pushbutton that closes the magnet contactor. The second contact is in series with the interlock that holds the contactor closed. After the second relay contact is opened the contactor opens, but cannot again be closed by the pushbutton until the bimetal has cooled sufficiently to close both contacts. This insures the contactor being closed in a positive manner after the pushbutton circuit through the relay contact has been established. The relay is normally made with two overload elements, one for each of the two leads to a polyphase motor.

Likewise, the *TA* relay is ordinarily made with two overload elements for use with polyphase motors. The two bimetal strips engage a common insulated rod which is lifted

Fig. 3—Bimetal-type thermal overload relay for protection of a.c. and d.c. motors having a rating of from 20 to 300 amp.
This *TC-221* relay has two overload elements, one connected in each of the two motor leads.



when the bimetal is heated by small resistor elements, which are located immediately beneath their respective bimetal strips. On overload the bimetal lifts the insulated rod sufficient to release the catch which permits a spring to open the relay contacts. After the bimetal has cooled the relay contacts can be reset. An adjustment is provided for setting the relay to trip at 80 to 120 per cent of the heater rating. Heaters can be provided up to 95 amp. in capacity, but above this value inexpensive series transformers are used.

Relays for polyphase a.c. motors usually have overload protection in two phases accorded by two separate heaters and bimetal strips, but often one set of contacts.

Fusible Alloy Relays—The heat-responsive element in this group of relays shown in Figs. 9 to 11, consists of an alloy similar to solder, which melts at a very definite temperature. When hard, this alloy holds the relay contacts closed against a spring tension. Heat is applied by means of a resistor or an inductive device in the motor circuit. When the load produces enough heat to melt the solder, the spring revolves a pin embedded in this alloy and moves the relay contacts to the open position. As soon as the alloy solidifies which it does very quickly after the load has been removed, the relay can be reset. These relays are sometimes called the solder-pot type. A brief description of three different relays of this general type follows:

The *I-C* thermal relay is a two-pole type with a common contact member as shown in Fig. 9. The alloy is contained in a cup or cylinder into which extends the stem of a ratchet wheel. This alloy is heated by a resistor element which is in series with the motor, so when an overload occurs the heat from the resistor element gradually raises the temperature until the alloy is melted. This permits a ratchet wheel to turn and release the mechanism which opens the relay contacts under spring pressure, and as soon as the alloy solidifies the relay can be reset. The rating of the relay is easily changed by changing the heater.

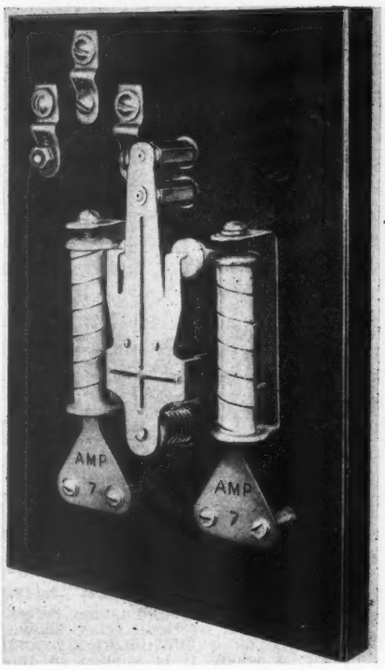


Fig. 5—A spiral-wound, bimetal-type overload relay.
In this *Thermaload* relay, a small resistor for heating the bimetal is inserted inside the spiral making a very efficient heating device. The calibration of the relay is changed by changing the heater elements.

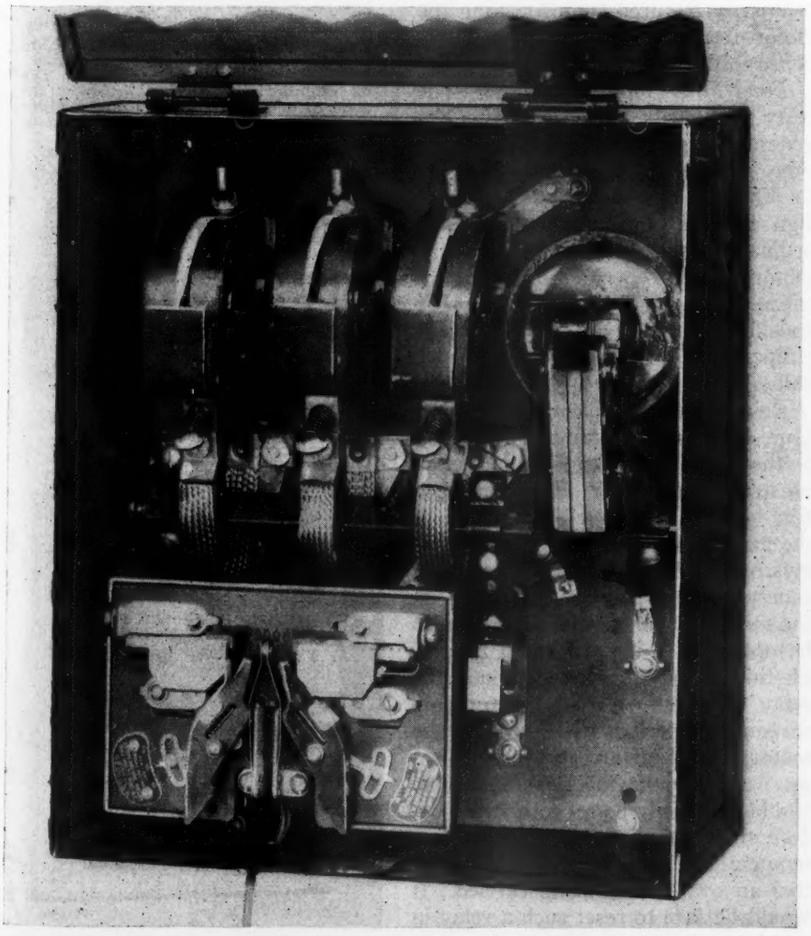


Fig. 4—Motor starter equipped with bimetal-type relay.
This *TC-121* relay has a maximum rating of 80 amp. and is suitable for use with motors up to 50 hp. in capacity.

In the *C-H* thermal relay Fig. 10, two heaters are associated with two thermal elements. The heaters are connected in separate motor leads. The thermal element consists of a stationary tube which encloses a spindle, the two being held together by a thin film of fusible alloy. When the motor is overloaded, there is sufficient heat to melt this allow and release the spindle, which rotates under the action of a spring and trips the relay contacts. The operation of either or both of the thermal elements trips the same set of contacts. The relay contact can be closed as soon as the fusible alloy hardens. The current at which the relay trips, can be adjusted over a 20 per cent range. This is obtained by varying the position of the cover carrying the thermal member with reference to the heater. Greater variations in tripping current are obtained by changing the heater coil.

The *A-B Inducto-therm* relay, however, differs from all other thermal relays in that the heat, causing the relay to trip, is produced by induction. The relay as shown in Fig. 11 is essentially a transformer, the primary coil of which is in series with the motor lines and the secondary is a copper element of one turn. The heat in the copper element or heater is due to current and resistance, the

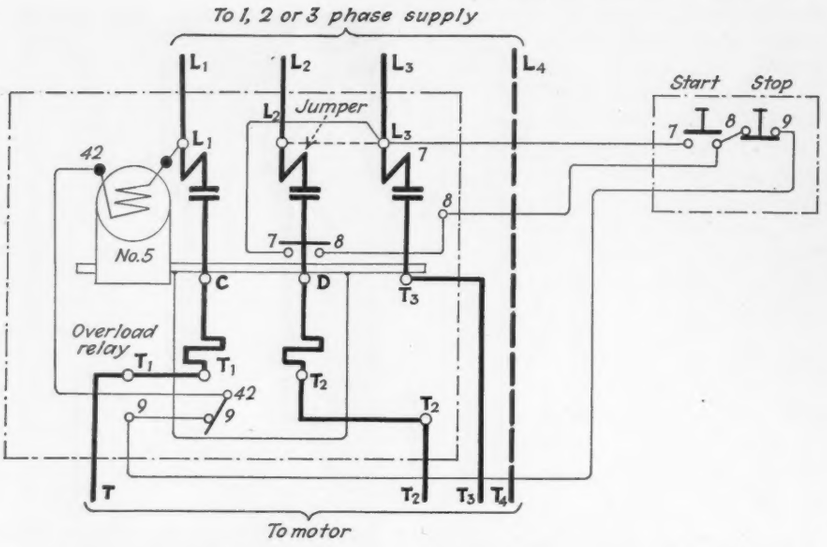


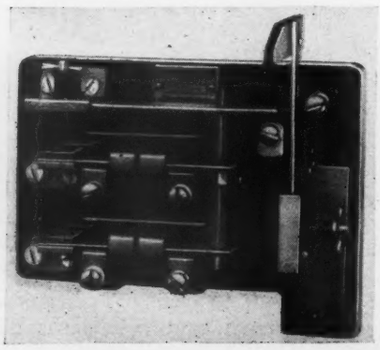
Fig. 6—Connection diagram of linestarter controlled by the "TA" relay.
The above connection diagram refers to the thermal overload relay shown separately as a unit in Fig. 7 and in Fig. 8 where it is applied in the enclosed type of commercial linestarter.

current being produced by magnetic induction. The magnetic flux linking the primary and secondary of the transformer is varied by moving an adjustable core which increases or decreases the air gap. The core, which is an iron screw, is readily adjusted, thereby providing a means for setting the relay to currents of motors of different horsepowers.

Relays for Larger Motors—The parts of these thermal relays which carry the motor current are small, and their maximum current rating is limited. When used with motors in excess of this rating some inexpensive form of series transformer is used. If the relay contact is not sufficient to handle the control circuit for these large controllers a small contactor can be used between the thermal relay and the main control circuit.

These relays will carry the rating stamped on the heater, increased by whatever adjustment is provided and will successfully withstand overloads up to 600 per cent of the heater rating, but the ordinary type of thermal relay must be protected by a fuse as it takes time for the heat to be transmitted from the resistor to the bimetal or alloy. Therefore, when a short circuit occurs the heater would be destroyed before the bimetal or alloy had time to respond, if it were not protected by a fuse. This fuse is ordinarily required for protecting the motor feeder and does not add expense to the equipment.

Fig. 7—Bimetal type *TA* thermal relay with two overload elements for use with polyphase motors.



Long-Time Thermal Relays—The relay ordinarily furnished for the general purpose motor may have a time element represented by 30 sec. to 30 min., depending upon the design and the percentage of overload ordinarily guarded against. Large motors have considerable thermal capacity and require several hours of considerable overloads to raise their temperature to an unsatisfactory value.

Relays are available which have a time element approximately as long as the motor. A relay of this type is illustrated in Fig. 3. Engineers differ, however, in their opinions as to the most desirable time element in relays of this kind. If the relay has a time-temperature curve the same as the motor it will permit the motor to be operated at its maximum output. If this output is exceeded and the relay functions, it will take a corresponding period of time for the motor to cool off and the relay to reset. A relay having a shorter time would ordinarily be set to operate before the motor reached a dangerous temperature and serve as a warning that an overload is being carried. It would be safe to reset such a relay in a shorter time than would require the motor to cool off depending upon the time element of the relay itself compared with that of the motor. If a relay is used having a long time element its performance should be carefully checked against the feed wires and control equipment and this part of the equipment selected of sufficient size to safely carry the load within the

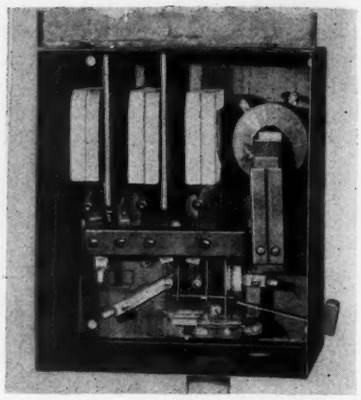
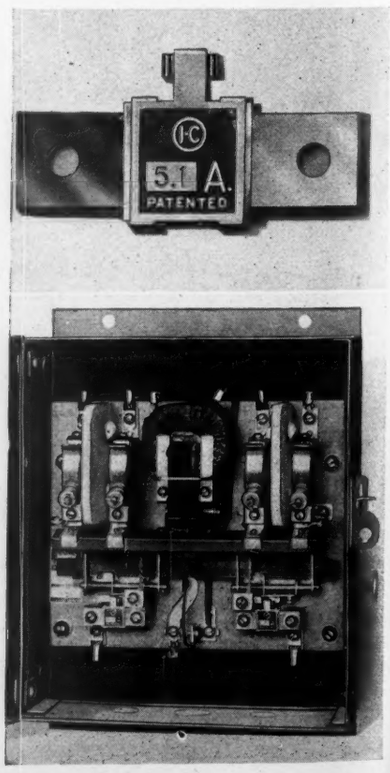


Fig. 8—Inclosed linestarter equipped with thermal overload relays.
The type *TA* relay contacts are reset by hand with the device at the right after the bimetal has cooled.

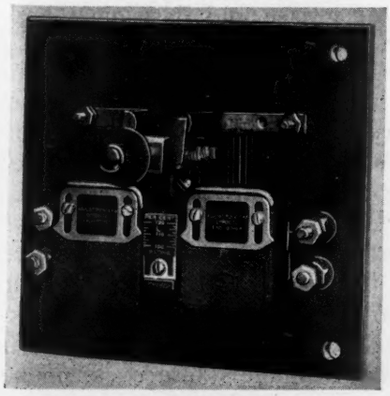
Fig. 9—Fusible alloy-type relay and its application in an automatic starter.
The relay shown at the top is a two-pole type with a common contact member. The alloy is contained in a cup or cylinder into which extends the stem of a ratchet wheel. In the lower view the relays are shown in each of the two motor leads.



tripping value of the relay. The advantages of a long-time overload relay can best be determined by experience. There are a number of problems in connection with thermal overload relays which will be worked out as our experience with this apparatus broadens. For many applications a relay with sufficient time element to start the motor up, when set close to the full load motor rating will prove satisfactory.

Thermal Cutouts—A discussion of the overload protection of motors would not be complete without mention of the thermal cutout. This fuses a current carrying member due to an overload in the same manner as a fuse, except that the cutout develops either part or all of its heat. A resistor winding which communicates the heat to the fusible member introducing a time lag which is much longer than that obtained with the ordinary fuse. Cutouts are available which have a sufficient time lag to permit the starting of induction motors at full voltage with cutouts that have a continuous rating not much in excess of the full-load rating of the motor. When a cutout opens the circuit, it is necessary to dismantle it and renew the fusible elements. For these reasons they are not as convenient as overload relays but are very suitable for manually-operated starting switches which do not have a low-voltage device which can be open circuited by a relay. Relays can only be applied to motor starters and controllers which have means for opening the main circuit when a small magnetic circuit is opened, such as magnetic contactors and low-voltage devices. When thermal cutouts are used the starter should be inclosed and should be operated from the outside. The starter should be so arranged that access cannot be had to the cutouts unless the starter is in the off position. When the inclosure has been opened to give access to the cutouts, the starter should be rendered inoperative until the inclosure has been restored. These are the same requirements as for fused switches on 150 volts and higher and are necessary for the protection of persons.

Fig. 10—A two-thermal element, fusible alloy-type relay.
In the relay, two thermal elements are associated with two heaters, which are connected in separate motor leads.



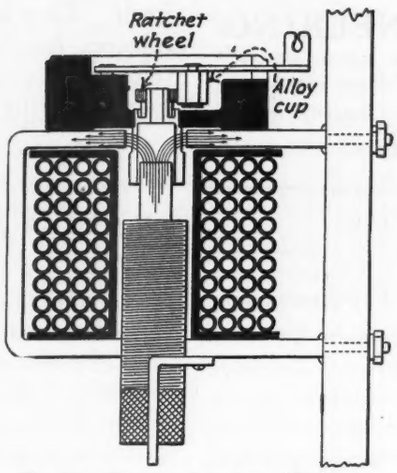


Fig. 11—Cross-section view of Inductotherm overload relay.
This alloy-type relay is essentially a transformer, the primary coil of which is in series with the motor lines. The alloy is contained in the small cup mounted in the top of the heater element. This alloy holds a ratchet wheel shown at top from turning when it is solid. An overload melts the alloy, permitting the ratchet wheel to turn and open the relay contacts.

Construction of Low Truck for Shop Use

IN MANY of the smaller shops there is no provision for moving heavy loads, such as machines and large and cumbersome boxes, by any means other than rollers.

The low truck described was devised by the writer, and has not only filled, but has exceeded all expectations for the above purpose.

The construction consists of two parallel frame pieces connected by a number of 1-in. cross-pieces and resting on four sets of casters. The cross-pieces are of oak and are screwed to the frame. The casters are of the double-wheel type, so that each truck rests on eight wheels. Several of these trucks were made so that machines set up on legs could be moved. Advantage can be taken of the lesser width occupied by placing four trucks parallel to the length of the machine rather than using but two trucks crosswise, that is, one at each end.

Jena, Germany. HENRY SIMON.

Subscription Swindler Gets 18 Months in Jail

THROUGH the efforts of the National Publishers Association, in co-operation with Mr. John Schaefer, Manager of the Trade Periodical Service Company, New York, a national subscription agency specializing in trade and technical papers, the fraudulent agent, "Peter Le Gaire," alias "Paul Leland," was tried recently in Philadelphia, found guilty by a jury of the Court of Quarter Sessions, and sentenced by Judge Samuel L. Reed to eighteen months in the county jail.

This agent was well known to many publishers of trade periodicals, as his dishonest practices were confined mostly to that field. His record shows that he began fraudulent solicitation of subscriptions in 1924, and during the latter part of that year, and in all of 1925, he operated in Southern, Eastern and Middle Western states, appropriating the name of the Trade Periodical Service Company, 1400 Broadway, New York.

During 1926 and 1927 he used the name of the Trade Journal Circulation Company, 269 Broadway, New York, using printed receipts with that name and address, although there is no such firm in New York City.

To protect the readers of McGraw-Hill publications against the operations of fraudulent agents, each subscription agent of this company is required to carry an identification slip similar to that shown in the accompanying illustration. The company seal is put across the photograph, so that there can be no chance of substitution. Subscribers are cautioned, therefore, in dealing with solicitors.

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INDUSTRIAL ENGINEERING

Application and Operation of Electrical and Associated Mechanical Systems and Maintenance of Plant Structures

Published by McGraw-Hill Publishing Company, Inc.

G. A. VAN BRUNT, *Editor*

New York, November, 1927

Capitalizing the Service to Production

IN THE old "easy" days of pre-war American industry, most of the effort toward improvements centered about the production functions. In fact a great many plant managers made a broad division, in accounts, between productive and non-productive labor. If the ratio of non-productive to productive labor was high, it was taken as evidence of bad management. Hence the pressure was in general toward reducing the non-productive items.

Strangely enough, it developed that there was no relationship between a low non-productive labor ratio and a good profit showing. On the contrary, many of the plants which made the largest profits had a high ratio of so called non-productive labor.

Out of this anomalous situation came the truth as we know it today. There is no such thing as non-productive labor. All labor is productive. The man who cleans the shop windows may increase the producing efficiency of the department ten per cent, through providing the operators with better light. His contribution to manufacturing profits may easily be greater than that of the mechanical genius who doubles the rate of output of a single machine. The influence of these so called non-productive jobs are tremendous, but it works two ways. The oiler who is responsible for lubricating a few bearings may, through neglect, shut down an entire manufacturing department for several hours, and cause more actual loss of production than if four or five operators were to spoil their week's work.

In addition to this there is another important angle to the cost saving possibilities on the Services to Production. This phase of plant operation often offers a rich field for cost savings through waste elimination. Having been less closely scrutinized by management than has production there are more undisclosed wastes. One can arrive at the efficiency of an individual production machine much more readily than at the inefficiency of the plant's power transmission or its handling methods. Losses in these services, which are part of the factory "overhead," are concealed and hard to get at. That is all the more reason for taking pains to unearth them. After the surface gold has been picked up the miner must dig deeper for his treasure.

Progressive plant managers today rank the importance of these and the many other non-productive functions which comprise the Services to Production on a par in importance with Production itself. They know that good or poor power transmission, handling methods, lubrication and maintenance may easily mean the difference between a manufacturing profit or a loss in a year's operations.

Radio—A New Tool for the Maintenance Department

IN ADDITION to its wide popularity as a fireside entertainer, and a medium for the transmission of news, radio bids fair to win recognition as a valuable aid in the inspection of electrical equipment. Radio receiving sets are being used by central station engineers to check up the condition of transmission lines. Such sets have also been employed by radio dealers and others to locate sources of interference with satisfactory radio reception in homes. Recent developments would seem to indicate that in a set having the proper characteristics, the maintenance department of industrial plants will have an extremely useful tool.

A few days ago an engineer discovered by the use of a portable receiving set that a medium-sized direct current motor driving a fan was not operating properly. Subsequent investigation showed that one of the commutator bars was low.

In another case, a manufacturer of radio sets discovered a number of cases of incipient trouble with motors, while seeking to clear up interference that was annoying when new sets were being tested.

In both of these instances a simple regenerative-circuit set of rather low sensitivity was employed. The defective motors were located easily, and without the necessity of getting close to them.

Much work will doubtless be required to determine the possibilities and limitations of this new tool, but the advantages which it offers warrant careful study. The editors will be glad to learn the results obtained by any readers who have used receiving sets for checking up the condition of electrical equipment.

Clean Bearings Seldom Are Out of Repair

A COATING of grease and dust on a bearing may be the direct cause of a fire. A clean, iron surface on a bearing dissipates heat with sufficient rapidity so that the ignition point is seldom reached. Grease, oil or dust over the bearing speeds up ignition, often to the point of a flash fire or, depending on the nature of the material, an explosion.

"The very effort necessary to cleanliness creates a higher morale. Pride on the part of the owners and managers carries down through the ranks. Clean bearings seldom are out of repair. The pride that induced cleanliness insures a smooth

running bearing, while the bearing that is buried in grease and dirt runs until it is too hot to continue."

Industrial operating men may well ponder over the above statement of Eugene Arms, Manager, Mutual Fire Prevention Bureau, Chicago, Ill., at the recent National Safety Congress, while discussing the relation of good housekeeping to fire prevention. The elimination of a fire hazard, however, is not the only reason for keeping clean the power transmission equipment.

Dirty bearings (excepting, of course, those in the industries in which dust abounds, such as cement manufacture and a few others) usually indicate neglect, and neglect generally spells trouble. If the bearing is inspected and serviced regularly and properly and the oiler has the right attitude toward his work, the accumulation of dust or lint is removed so that it cannot enter the bearing when servicing. Even anti-friction bearings lubricated by the pressure gun system should be wiped off to prevent dirt which has settled on the grease or oil fitting from being forced into the bearing.

Some serious fires have resulted from neglected and dirty bearings; however, the monetary value of the lost time and interference with production from this same cause probably exceeds the loss from fire. Thus the necessity of keeping bearings clean applies to every type of plant, even though the dusts are not combustible. Also, "a good oiler is known by the bearings he keeps in service."

How Many of Your Belts Are Overloaded?

PROBABLY 90 per cent of all trouble with belts is caused by overloading. This opinion was recently expressed by an engineer who has had many years of experience in designing industrial power drives. In explanation of this statement, he pointed out that much still remains to be learned about the transmission of power by belts. Thus sheer ignorance leads to many errors in calculating the size of belt required for a given application.

Again, differences in the quality of the leather, and variations in the tanning process and subsequent treatment, make a great deal of difference in the power-transmitting capacity of belts. This is one of the reasons why one belt may be able to pull a given load with a fair margin of safety, whereas another belt of the same width and thickness and to a casual glance apparently identical in every way, will fail long before the other one, under the same load.

It is unfortunate, not to say inexcusable, that responsibility for overloaded belts frequently rests with the designers of machines, who provide their equipment with pulleys that are too narrow, or too small in diameter, or both. When the design of the equipment is such that larger or wider pulleys can not be used there is nothing to do but make the best of a bad situation, and accept belt trouble and short life as inevitable, unless some other type of drive can be employed.

Failure to realize that putting new machines on a lineshaft, increasing speeds, and otherwise changing operating conditions may seriously overload the belt drives, is another prolific source of trouble.

A belt of good quality, when properly loaded and cared for, will give a good many years of trouble-free operation. Whenever a belt does not perform in this manner, it is the part of wisdom to determine whether that belt is being loaded beyond its capacity.

Study Effect of Rearranging Equipment On Power Drive Layouts

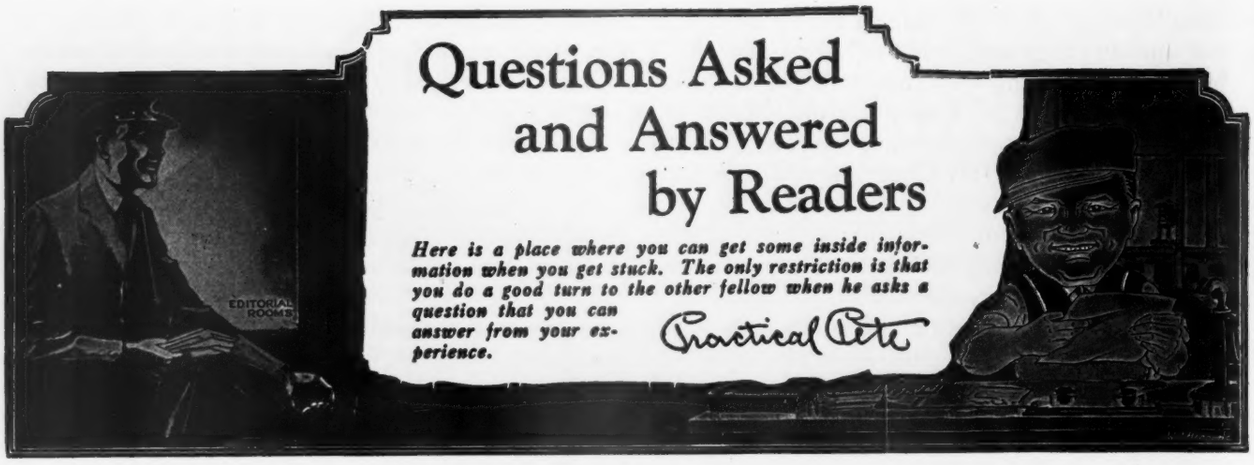
INCREASED production schedules frequently make it necessary to rearrange production machines, or add new units. From the production standpoint such changes may be simple and easily accomplished, but they often present power drive problems that need careful attention.

Any rearrangement of machines should be preceded by a close study of its effect on the existing methods of driving them, unless individual drive is used throughout. In this case overloading of feeders is one of the main points that requires checking. However, when machines are driven in either large or small groups from lineshafts, the question of overloading, or making existing equipment fit the new conditions becomes of prime importance. Even so simple a procedure as speeding up a lineshaft should not be regarded as of no consequence. An increase in speed or the addition of one new machine may overload a belt drive sufficiently to cause no end of trouble.

Again, decreasing the center distance between shafts may, by reducing the arc of contact on the small pulley, lead to excessive belt slippage and wear.

Oftentimes the troublesome and expensive drives that can be found in almost any plant can be traced to changes that were hurriedly made to meet production demands. The wishes or needs of the production department must, of course, be given careful consideration, but that is not sufficient excuse for installing makeshift drive arrangements, or attempting to lay out a satisfactory drive under impossible conditions.

An emergency may justify the use of makeshifts, but there is no hope of obtaining trouble-free service from power drives or other equipment that is installed or operated without regard to good practice.



Questions Asked and Answered by Readers

Here is a place where you can get some inside information when you get stuck. The only restriction is that you do a good turn to the other fellow when he asks a question that you can answer from your experience.

Practical Pete

QUESTIONS

Who Can Answer These?

Adjusting Double-Reduction Chain Drive

I have three shafts connected by two silent chains which must operate with fixed center distances between the shafts. This does not permit shifting the shafts for adjustment of the distances between them to compensate for wear or stretch. The drive will operate satisfactorily with a new chain for a year or two but after that it causes considerable trouble. Could any reader offer any suggestions on overcoming my difficulty with this drive.
Chicago, Ill. N. H. N.

Difficulty With Arc Welding Rods

Frequent trouble with one or more of our arc welding machines, which operate from 10 to 15 hr. per day, is due to the weld rods suddenly becoming red hot from tip to handle. The result is that instead of the molten metal on the end of the rod adhering to the weld, it only drops off to lay on the surface. Although we have found out that a machine giving trouble will run properly after a 5-min. shutdown, several tests failed to reveal the cause of the trouble. We shall appreciate readers telling us the reason and remedy of our difficulty.
Harvey, Ill. H. J. B.

Transformer Core Inspection

In order to make room for some new equipment we wish to move some of our transformers. The proposed location for them will cause some inconvenience whenever the transformer cores are removed. So we are interested in learning from readers how often the cores should be removed. Also, what methods are used in inspecting and cleaning the cores?
New Orleans, La. F. H.

Determination of Power Factor for Synchronous Motor

We have a 170-hp., 220-volt unity power factor, synchronous motor that operates at 50 per cent of its rated load. When the maximum excitation current of 8.1 amp. is employed from its direct-connected exciter, a leading power factor of 70 to 80 per cent is obtained at the motor, and at unity power factor the excitation current is 5 amp. As the plant power factor is 86 per cent when this motor is not operating, I shall be pleased to have readers explain the method of determining the proper power factor at which to operate this motor.
Chicago, Ill. H. F.

Voltage Regulation of Three-Phase System

Assume equal spacing between all three lines of a three-phase line having two induction-voltage regulators of 10 per cent rated regulation at the receiving end. If a balanced load is increased indefinitely, will each phase continue to receive the same amount of automatic regulation; that is, hold the same regulated voltage until both regulators reach the maximum boosting position? If not, how much regulation per phase can be given by this connection of regulators with indefinitely increasing balanced load? The connection of regulators referred to is this: In a three-phase line, ABC, regulator No. 1 is connected with its series coil in line A, and the potential terminals connected across phase AB; so that if a test were made with the regulator rotor in a boosting position and line C entirely removed from source to the load during this test, phase AB voltage would be boosted. No. 2 regulator is connected with its series coil in line C, and the potential terminals connected across phase BC; so that a test made with the regulator rotor in a boosting position and line A entirely removed from the source to load during the test would show the voltage of phase BC to be boosted. We shall appreciate readers giving vector diagrams to illustrate the points in question. Also, is the two voltage-regulator system of regulation in three-phase circuits considered superior to three single-phase regulators electrically as well as economically.
Beardstown, Ill. F. H. L.

Size of Leads for Secondary of Instrument Transformer

On our incoming lines we have an inclosed, tank-type metering outfit which contains 200 volt-amp. instrument transformers serving a G. E. DS-6, polyphase wattmeter. We have had so much trouble from fluctuating power that we want to obtain a graphic record of the load and voltage, but it will be necessary to install the meters 2,700 ft. from the metering tank. Will readers tell me if this can be done without affecting the registration of the watt-hour meter, and what size secondary circuit will be required to compensate for the drop, so that true registration will be obtained with the graphic meters?
Worcester, Mass. D. E. M.

ANSWERS

Received to Questions Asked

What Determines Minimum Thickness of Brushes?

I recently tried to eliminate sparking on a d.c. compound-wound generator by reducing the thickness of the brushes from $\frac{3}{4}$ in. to $\frac{1}{2}$ in. This reduced the sparking, but the commutator became so hot that it turned blue. Will readers please tell me (1) what limits the minimum thickness of brushes for d.c. motors or generators, and (2) how can I overcome this heating without using a thick brush which will again cause sparking?
New Haven, Conn. J. R. S.

ANSWERING the question by J. R. S., if the machine in question is of an old type—that is, made before 1910—it is more than likely that it has no interpoles, and if it gave satisfaction prior to the investigation and experiments by J. R. S., the trouble probably lies either in the brush spacing or setting, the quality of brushes, the field or the armature section. However, if the machine has always given a certain amount of sparking trouble, it may not be possible to eliminate the sparking entirely, because of faulty design.

One of the best things to do in a case like this is to ascertain if the brushes are secured in their neutral position. This is important and should be given careful attention, because the moving of some brush holders only a fraction of an inch out of the neutral position will cause sparking of the brushes.

One way of testing the neutral position is to operate the machine under load and then move the brushes until a minimum amount of sparking results.

On commutating-pole machines the electrical neutral should be accurately located and a voltmeter should be employed to determine the running position of the brush holder. When making such a test the voltmeter terminals should be connected on either side of one main pole. During the test the brushes are raised and the armature remains stationary.

After the shunt field is excited to about one-half the normal voltage, the circuit should be quickly broken. As the transformer action induces a current when the field circuit is opened, a voltage will be indicated on the meter, preferably a 5-volt meter, either in a plus or minus direction according to the side of main pole centers these connections are made. By moving the voltmeter terminals a point will be found where no voltage will be indicated when the field circuit is broken. The brushes should now be set at the neutral point thus determined.

If a thinner brush is employed, it will, of course, be necessary to use a brush with a lower resistance. In J. R. S.'s case I believe that the narrow brushes have not sufficient capacity and consequently overheat.

Although excessive brush tension will also cause them to heat, on non-commutating pole machines brushes of a higher resistance are generally necessary. Usually on non-commutating machines the brush contact resistance is from 0.3 to 1 volt, but, of course, when the brush heats up, the contact resistance is lessened. In this case more current flows when passing from one segment to another and the brush has a greater tendency to heat. A brush current density of about 35 amp. per sq.in. should be the maximum amount of current allowed to flow through them and a brush tension of from 2 to 3 lb. should be sufficient. GRADY H. EMERSON.

Birmingham, Ala.

Charging Storage Batteries From Exciter

In our plant we have a combination signal and fire alarm system operated from three 6-volt, lead batteries connected in series. Instead of sending them out every month, I want to charge them from the 125-volt exciter on our generator, which is in continuous service. In order to lower the voltage for charging I want to use a number of spare cast-iron grids that are kept on hand for a 50-hp. motor. Will readers, therefore, suggest a method of determining the resistance per grid, so that I can determine how many to use? R. C. B.

Grenada, Miss.

REPLYING to the question by R.C.B., the value of the fixed resistance may be determined in a general way as follows:

Obtain from the battery manufacturer complete details regarding the battery; that is, what should the normal, continuous charging rate be, or the trickle charge rate be, if these batteries are not to be used continuously for any extended period of time.

Since the maximum voltage of a 6-volt battery will not exceed 7.5, it will be necessary to provide a minimum resistance to take care of 125 — 7.5 = 117.5 volts at the ampere rate given to the battery; so 117.5 divided by this rate will give the minimum resistance in ohms to be used.

At the trickle charge rate, the battery potential will be practically 6-volts; the resistance in circuit will then be required to take care of 125 — 6 = 119 volts.

Assume, for example, when the resistors are connected as shown in Fig. 1, that the maximum charging rate will be 5 amp. Then a resistance of 117.5 ÷ 5 = 23.5 ohms will be required, and if the trickle charge was 0.5 amp., a total resistance of 119 ÷ 0.5 = 238 ohms will be needed. It is clear, of course, that the added resistance for the trickle charge rate of 238 — 23.5 = 214.5 ohms would have only a continuous capacity of 0.5 amp., and, therefore, could be made up of a resistor of the tubular type. It is necessary, usually, to arrange the charging circuit so that the sections of resistance may be switched in as required.

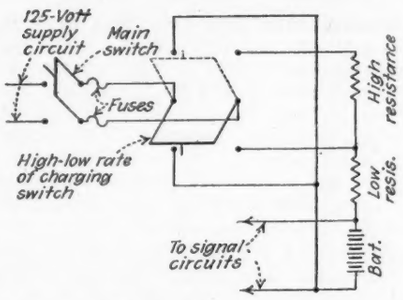


Fig. 1—This arrangement of two resistors allows a high or a low rate of charge.

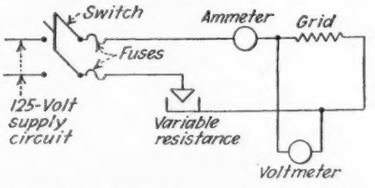


Fig. 2—How to connect a grid to find its resistance.

The resistance per grid could be determined by connecting a lamp bank or water resistance in series with the grid or group of grids, as indicated in Fig. 2, and also inserting an ammeter in the circuit. When the current is flowing measure the voltage across the grid or grids. The resistance may then be calculated from the formula R = E ÷ I; when R = resistance in ohms, E = volts, and I = amperes.

C. OTTO VON DANNENBERG.

Electrical Division,
General Engineering & Management Corporation,
New York, N. Y.

ANSWERING the question by R.C.B., perhaps the simplest way of determining the resistance of the cast grids, which R.C.B. wishes to use as charging resistors, is that commonly known as the drop of potential method.

With this method a grid or number of grids may be connected in series, and a current passed through them, either from the exciter or from the batteries supplying the signal circuits.

While this current is flowing, the voltage across the grid or grids is measured with a voltmeter and at the same time an ammeter reading should be taken. From the simultaneous voltage and current readings, the resistance may be determined from the formula, resistance = voltage ÷ amperes. V. E. JOHNSON.

Milwaukee, Wis.

REPLYING to the question by R.C.B., the resistance of the grids can be measured by connecting several grids in series with the 18-volt battery, adjusting the number of grids used until about 10 amp. is flowing through the grids. Then to obtain the resistance of the grids in ohms divide the voltage drop across the grids by 10 amp. The resistance per grid may now be determined by dividing the number of ohms thus found by the number of grids used. It is probable that R.C.B. will find the grids too heavy for the purpose he has in hand. If so, I would suggest the use of one of three other methods.

A serviceable resistance for the work can be made by coiling about 20 ft. of No. 20 Nichrome or Chromel A wire connected in series with a charging circuit and wound on an insulator.

If a 1,000-watt radiant heater is connected in series with the charging current, it would allow just about the proper amount of current to flow from the 125-volt line to the batteries.

As a means of charging the batteries continuously, even when being used, one 125-volt, 8-cp. lamp may be connected in each of the two lines leading from the exciter; in this way the voltage between the signal wiring and ground is reduced.

Chief Engineer, J. F. MORGAN.
Mercury Mills Ltd.,
Hamilton, Ont., Can.

IN ANSWER to the question by R.C.B., although the resistance of a grid may be determined in several ways, I will mention only two ways.

If a voltmeter and an ammeter are available, the resistance of a grid or a group of grids may be determined by noting the voltage drop around the grid or grids and the amount of current flowing. The resistance can then be calculated from the formula, R = E ÷ I, when R equals resistance in ohms, E equals voltage and I equals current.

In case an ammeter is not available, but a voltmeter is, then the resistance of a grid may be determined by connecting it in series with a known resistance. When the current is flowing, determine the voltage drop around the known resistance. Then the amount of current flowing can be determined from the formula I = E ÷ R. Next determine the voltage drop around the grid. The resistance of the grid may be determined by dividing this voltage by the current flowing in the circuit, as determined

by employing the known resistance.

As a means of varying the charging current, taps may be connected between the grids. These leads may then be connected to a short-circuiting switch or switches.

If the charging current should be interrupted at any time, current would flow from the batteries. So to prevent this some device should be installed to open the charging circuit whenever the charging current fails.

Lansdale, Pa. HORACE TURVILLE.

IN ANSWER to the question by R.C.B., I would suggest, as a convenient method, the use of a bank of lamps instead of the spare grids. With a bank of 120 to 125-volt, 32-cp., carbon lamps, a maximum of 10 amp. for the charging current is available. By this method it is possible to apply a charging current of from 1 to 10 amp., without the use of an ammeter, by simply screwing in the desired number of lamps. E. J. ELVISH.

Kaminstiquia Power Co.,
Fort William, Ont., Can.

Repulsion-Induction Motors Fail to Start

Several new ¼- and ½-hp., 110/220-volt, single-phase, repulsion-induction motors operated satisfactorily for a few months, but now they either fail to attain full speed or refuse to start even under no load. Sometimes when the armature is turned over so that the brushes touch a different bar, the motor will start. The commutators are not rough or badly blackened, and tests indicate that the motors are in good condition. A receiver test, made when the short-circuiting device is removed, indicates that there are no open circuits in the armatures. Dead spots on the commutator do show up, but when it is turned over a few bars, these dead spots give a good test and the parts which previously indicated a good test give a poor one. Operating these motors under ideal voltage conditions does not help to cure the trouble. Will readers please suggest the cause and remedy for the trouble with these motors?

Quebec, Can. W. S. B.

REPLYING to the question by W.S.B., the voltage at the motor should be checked because the power of an a.c. motor varies as the square of the voltage, and occasionally low voltage causes trouble. Usually these motors are designed to operate satisfactorily if the voltage does not vary over 10 per cent. Transformers with poor regulation sometimes cause trouble with this type of motor.

The motor should be checked carefully for poor contacts and loose connections, and the governor mechanism should be examined and tested to see whether it functions at the proper time. Occasionally the governor mechanism needs to be adjusted to suit the load. Worn bearings, which cause a roaring sound when the motor is started, will cause trouble, although the rotor may not be rubbing on the stator.

The brush setting may need adjusting. This can be done while the motor is running by loosening the setscrew and then moving the brushes until the correct position is found. After the brushes have been set, their position should be marked. With fractional horsepower repulsion-induction motors special care should be taken to make certain that the brushes are making good electrical contact with the commutator bars.

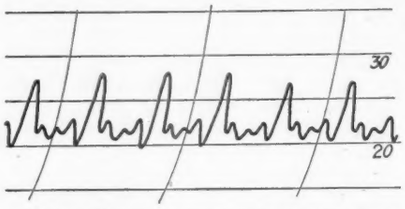
If the motor still continues to give trouble, the windings must be tested, and several tests should be made: namely, for grounds between wires and frame, and for open circuits, and shorts between wires.

GRADY H. EMERSON.

Birmingham, Ala.

Interpretation of Graphic Meter Record

I have run several tests on a gear-driven duplex plunger pump and should like to know why the graphic wattmeter records are as shown below instead of being a straight line, thus indicating a steady power input. The cranks on opposite



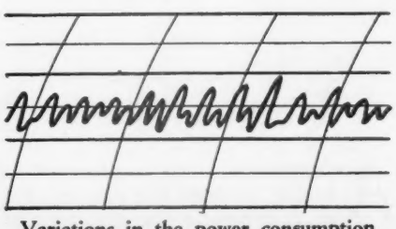
sides of the gear are set at 90 deg. Will readers please tell me whether such a chart is normal, or is due to defects in the meter, or in the pump or motor. Also, can grapic meter records be used to detect or locate pump troubles?

Detroit, Mich. S. B.

IN ANSWER to the question by S. B., the chart indicates to me that there is some obstruction in one valve or passage at one end of one cylinder. The high points in the chart accompanying the question are probably due to the extra power needed to force the water past the obstruction. Although there may be a faulty valve in one of the cylinders, I doubt it.

The accompanying illustration shows a section of a chart taken by a wattmeter connected to a motor-driven, three-cylinder, single-acting plunger pump. Before investigating the performance of this pump we decided, after examining the chart and the action of the pump, that the suction valve on one cylinder did not feed properly, thus causing the irregularity in the cycles indicated by the curves on the chart.

When charts are taken of rotary and centrifugal pumps, the curve should be approximately flat. Trouble in pumps of this type is more difficult to detect than in reciprocating ones. It is possible, however, for an experienced man, when furnished with the characteristics of the pump, to determine approximately when a centrifugal pump is discharging its usual amount of water.



Variations in the power consumption of a three-cylinder, single-acting plunger pump.

Plant Engineer, H. D. FISHER.
New Haven Pulp & Board Co.,
New Haven, Conn.

REPLYING to the question by S. B., the graphic meter record curve is a good one for certain types of duplex pumps. In fact, any type of piston pump or compressor when in good condition should make a curve as good as the one shown with the question.

It will be noticed from the curve on the meter that on the intake or suction stroke the power consumed is small but increases at the beginning of the discharge or compression stroke until the piston has reached the end of the stroke.

If either the suction or discharge valves were intermittently sticking open, the curves would be irregular, or if one cylinder were doing more work than the other, every other curve would be different, in which case the pump would not work evenly. With a centrifugal or rotary pump, however, a curve that is nearly flat or straight should be obtained whenever the load is approximately constant.

Los Angeles, Calif. J. W. BANTAU.

Emergency Lighting from Current Transformer

We have a 440-volt motor in service at a considerable distance from the 110-volt lighting system. In the one phase of the motor circuit there is a 20:5-amp. current transformer for operating overload trips. Inasmuch as we do not want to extend the lighting system for only one lamp, and do not wish to install four lamps in series, will readers tell me whether I can cut a lamp in the secondary circuit of the current transformer? If so, what size and type of lamp should be used?

Superior, Wis. A. K. R.

IN REPLY to the question by A.K.R., the questioner is cautioned against attempting to accomplish the result desired without due consideration of the factors involved.

The voltage on the secondary side of a current transformer varies in value, depending on the motor load. Therefore, even for a fixed load, the voltage may be very low, although, for instance, a 20:5 ratio transformer were operated at a 10-amp. load. Since the normal rating of such a transformer is about 50 va., the voltage would be, neglecting other factors, not more than 10 volts maximum at full load, and this, of course, would vary with fluctuating loads.

If the lamp was connected directly across the secondary of the transformer, in multiple with some other device, it would interfere with the operation of that device; if connected in series, there would be the danger of the lamp opencircuiting and thereby on account of the high voltage induced at the secondary

terminals, possibly causing damage to the current transformer.

It might be possible to get a special low resistance lamp to give a more or less satisfactory result, but in any event the result obtained would be a poor one.

If the expense of installing a 440:110 potential transformer is too great, a comparatively cheap way of accomplishing the desired result would be to connect a 110-volt lamp in series with a tubular resistance across the 440-volt leads. This construction would require two sockets and a resistor that could be screwed into one of the sockets; the circuit to be arranged so that the resistor was in series with the lamp. The Ward Leonard Co., as well as other manufacturers, could furnish such a type of resistor at a small expense.

It would even be better to install four 110-volt lamps in series rather than attempt, in any way, to make use of a current transformer's secondary circuit for such a purpose.

C. Otto von Dannenberg.

Electrical Division,
General Engineering & Management Corporation,
New York, N. Y.

REPLYING to the question by A.K.R., do not attempt to install a light in the secondary circuit of a current transformer. To do this will prevent the protective apparatus connected in the secondary circuit from functioning properly. In addition to this disadvantage probably insufficient light will be obtained and in case the lamp burns out, the transformer will build up a voltage that may injure the transformer as well as the operator.

To furnish light for this installation it may be advisable to install a 440:110-volt transformer. A transformer suitable for this work, which is small, compact and air cooled, may be obtained at a reasonable cost from several manufacturers of electrical equipment.

Guy H. Wintersteen.

Cleveland, Ohio.

IN REPLY to the question asked by A.K.R., it is not practical to install a lamp in the secondary circuit of a current transformer.

To place a lamp across the secondaries of this current transformer will, in reality, as far as the lamp is concerned, act about the same as though the lamp was cut in series with a line leading to the motor, except that the current available in the secondary of the current transformer is only one quarter of the motor current, as the ratio of the current transformer is 20:5. So, as the load on the motor varies, the current supplying the motor will vary, thus causing the current in the secondary of the transformer to vary. These changes will cause the current available for the light to vary anywhere from 0 to 5 amp. Also, when the motor is stopped it will not be possible to light the lamp, and when the motor is running, I doubt if the light from the lamp will give satisfaction.

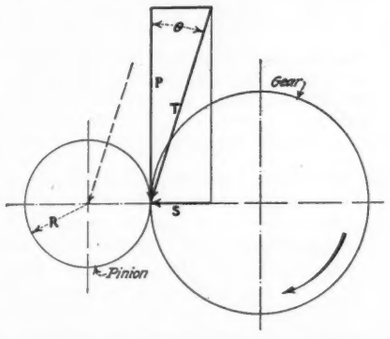
Probably the most inexpensive method of furnishing light at the motor can be accomplished by connecting two 220-volt lamps in series across one phase of the power circuit. A. C. Barker.

Chief Electrician,
W. S. Libbey Co.,
Lewiston, Me.

Location of Motor Pinion

Is there a preferred location of the motor pinion with respect to the driven gear? The accompanying diagram shows four different drive arrangements, one having the motor pinion on top of the driven gear, another with the pinion at the bottom, and others with the pinion on either side of the gear. The direction of rotation of the gear and pinion is indicated by the arrows. Which of these locations if preferred from the standpoint of stress on the motor frame and on the foundation bolts, lubrication of gear and pinion, and ease of maintenance and inspection? Are they all equally good? I should like to have some of our readers discuss this question, and give me the benefit of any experience they may have had with such a problem.
Landgraff, W. Va. U. J. S.

THE accompanying force diagram shows the lines of application of the two forces of a pair of meshing spur gears. This, I believe, will help U. J. S. to get a better understanding of his gear drive problem.



Application of the forces or pressures of a pair of meshing spur gears.

The tangential force, P, is calculated from the formula: $P = (63{,}000 \times \text{hp.}) \div (\text{r.p.m.} \times R)$

Where hp. = horsepower of motor.
r.p.m. = revolutions per minute of motor.
R = pitch radius of motor pinion in inches.

The angle θ is equal to 14.5 deg. plus 3 deg. The tooth contact angle, also known as tooth pressure angle, is 14.5 deg. for involute cut teeth, which are most generally used. The friction angle is assumed to be 3 deg., which, with the 14.5 deg. added, equals 17.5 deg.

The force S, tending to spread the two gears, due to the tooth pressure angle, is equal to: $S = P \times \tan \theta$. The resultant pressure T can be found graphically or by calculating $T = \sqrt{P + S}$. The arrows indicate the direction of the force. The pressure T is that which acts on the bearing of the motor and in the direction as shown by the dotted line.

Motors, except the ball- and roller-bearing types, are generally equipped with ring-oiled sleeve bearings. Because of the nature of the design, ring-oiled bearings have the upper half cut to take the oil ring. This reduces the bearing surface to some extent, although it is taken into consideration in the design of the bearing; however, there is more bearing surface in the lower half and therefore the arrangement B, as given by U. J. S., would be more desirable. The lubrication conditions are improved in this arrangement, because the oil is fed over the shaft which wedges the oil between the shaft and bearing in the direction of rotation.

The stress on the motor bearing and frame is down 17.5 deg. from the vertical, which will aid in holding the motor in place. The drive shown in A of his diagram gives the reverse conditions just mentioned for position B. By turning the force diagram to suit arrangements C and D, it will be noted that the resultant pressure is toward the side of the motor, thus requiring the motor to be doweled in place. Split bearings are most likely used on the gear shaft, however, and the pressure would be toward the split or joint between the two bearing halves. Wear would start at this point and would be more rapid than if the pressure were directed toward the more solid upper or lower halves of the bearing. In practice all the arrangements shown are used with equally good results, although preference should be given to arrangement B, where possible, for easy maintenance, inspection, lubrication and good mounting. E. H. Laabs.

Engineering Department,
The Cutler-Hammer Mfg. Co.,
Milwaukee, Wis.

THE gear arrangement shown at B in the diagram accompany U. J. S.'s question is to be preferred, because with this arrangement there is a downward thrust on the bearings of the shafts supporting the gears, whereas the arrangement in diagram A produces an upward thrust on the bearings and consequently increases the load on the holding bolts and the bearing caps.

From a lubrication standpoint the arrangement at B is also to be preferred when the gears are enclosed in a sheet metal or cast-iron gear case with its dividing line along the center line of the gears, thereby preventing leakage of oil. With this arrangement the rotation of the gears is such as to lift the oil a shorter distance to the mesh line than is the case with the arrangement shown at A.

Ordinarily it is much easier to inspect and maintain gears mounted horizontally than is the case when one gear is above the other, because covers can be removed without disturbing the bearings. Another difficulty encountered with the vertical arrangement is that when the bearings wear there is danger of throwing the gears off the mesh line, and if the upper bearing should wear more than the lower one, there would be a tendency to crowd the teeth together and cause faulty operation.

C. E. Schirmer.

Chief Engineer,
Toledo Crane Co.,
Bucyrus, Ohio.

Electrical Service

AROUND THE WORKS

For this section short articles describing ideas and practical methods devised to meet particular operating conditions are invited from readers. The items may refer to inspection, overhauling, testing, and emergency or special installations.

How an Electric Heater Lowered Cost of Heating Water

ELECTRIC heat has been adopted for heating bath water on holidays or other days when most of the employees of the Valier Coal Co., Valier, Ill., are not working.

This addition to the existing heating system was found necessary because of the high cost of furnishing hot water to the maintenance and construction men, who frequently have to work outside of regular working hours.

Hot water during regular working hours is provided for 600 men from a steam-heated system. The operation of this system requires 5 tons of coal per day and the services of three firemen, thus entailing an expense of $34.25 per day.

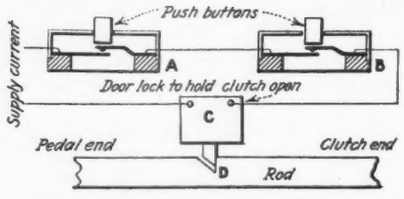
As only about 15 maintenance and construction men are employed, it was deemed advisable to install an electric water heating unit, which is capable of providing hot water for 50 or more men. With this electric heating system the water reaches bath temperature in three minutes after the current is turned on.

Some of the equipment to be provided with hot water consists of seven hot-and-cold showers. The water is heated in a 235-gal., heat-insulated, hot water tank by six 5,000-watt, 220-volt, helical sheath-wire immersion heating units furnished by the General Electric Co. Heating is governed by complete thermostatic control, and the installation is so arranged that it will not interfere with the heating of water by steam.

It has been found that the cost of electrically heating the water on idle days is about $7.65, which means, of course, a substantial saving over the steam system method of heating water at such times.

Installation of Safety Lock on Pedal-Operated Machine

SOME time ago I was asked to devise some sort of positive method for preventing operators of punch presses from getting their fingers caught under the dies. On these presses the operation of the die is controlled by a foot pedal. In one particular plant where I was engaged various mechanical devices had been tried out on the presses, but none of them proved satisfactory. So I built an electric device for releasing the foot pedal at the proper operating time of the machine.



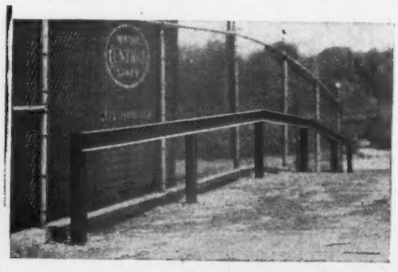
The clutch rod is held by the catch at D until the lock, C, has been released by pushing the two buttons, A and B.

The accompanying diagram shows how the clutch of a punch press can be held open until the operator's hands are clear of the die and the press. Buttons *A* and *B* should be placed one on each side of the machine so that it will be absolutely necessary for both hands of the operator to be clear of the work on the press before the machine can be made to operate. When both *A* and *B* are pushed, an electric circuit is completed through the door lock *C*. When the door lock is energized, the catch at *D* is released, thus allowing the rod, which engages the clutch, to be operated by the foot pedal.

CHAS. A. PETERSON.
Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

Simple Method of Constructing Steel Guard Rail

SEVERAL months ago a truck backed off the ramp of our shipping room, smashing the fence and the side of a freight car. To prevent a reoccurrence of this incident, a guard rail was erected, as shown in the accompanying illustration.



It took two men approximately 4 hr. to install the posts, which were made of 4-in. x 3-in. x ½-in. angle iron. However, less than 30 min. were required to weld the rails to the posts. Two 3-in. x 2-in. x ⅜-in. angle irons were used for the rail because they happened to be stock material. We now have a very substantial guard rail.

A. F. DAVIS.
Vice-President,
The Lincoln Electric Co.,
Cleveland, Ohio

Generator Overload Relieved by Idle Exciter

A LEATHER plant was faced with the alternative of either increasing their generating capacity or else cutting down their lighting load. Their generator was a belt driven machine rated 140 amp. at 115 volts, and when the full lighting load was thrown on, the ammeter frequently indicated 175 amp. As a result numerous shutdowns were necessary from excessive heating and flashing at the brushes. In view of this overload, they had been advised to get a larger generator but the expenditure was not approved because the management argued that there had been no overload the previous Winter.

On my arrival, after I had been called in on this job, I found the generator so hot that I could not touch the commutator even though it had been shut down for some time. When looking for the cause of the flashing I found that the heat had been great enough to melt the solder out of one of the commutator risers, thus opening one side of the two parallel windings, and consequently throwing all the load on the other winding for an overload of 100 per cent.

After soldering this lead in again, I looked around for the cause of the overload and found that they had added an entirely new machine shop and offices during the summer, besides increasing their lighting load in the plant itself to some extent, which accounted for the fact that there had been no overload the previous winter. In the engine room, I was shown a 550-volt alternator with a belted exciter, which had not been used for over 5 yr. This fact was apparent from the dirty condition in which I found it. The exciter was rated 30 amp. at 125 volts, which was just about the right capacity to give relief to the main generator. It took me 3 hr. to clean that exciter for I had to dig the dirt out of the oil wells with a knife.

After a thorough clean-up, the small exciter was swung up in front of the main generator, which was driven from the main drive shaft in the engine room, and an extra pulley was placed on the driveshaft beside that of the main generator. The next problem was to connect the pair of generators so that each would take its share of the load. It was obvious that they could not be connected in parallel, for their characteristics were dissimilar; that is, one generated 115 volts, while the other generated 125 volts at full load. In addition, a total failure of the large generator would have thrown the full load onto the small one, probably with disastrous results.

Looking over the main distribution panel, I found three small switches, strap-connected to the main bus, whose total load as read by an ammeter was 30 amp. After disconnecting these straps from the bus, I connected them with a pair of No. 10 jumpers to the blades of a double-pole, double-throw knife switch and to the three switches mentioned.

I wired the small generator to one set of terminals of the switch, while to the other set of terminals I connected a pair of No. 10 jumpers to the 110-volt a.c. city mains, so that in case of trouble or a shutdown in the generator or shafting service would be uninterrupted by switching to the auxiliary city service. This solved their problem in a simple and economical manner. No trouble was experienced with the small generator for it excited itself at once, which speaks well for the machine, considering that it had lain idle and neglected for 5 yr. The ammeter on the large generator never goes beyond 140 amp. now, while the small machine runs along steadily at 30 amp.

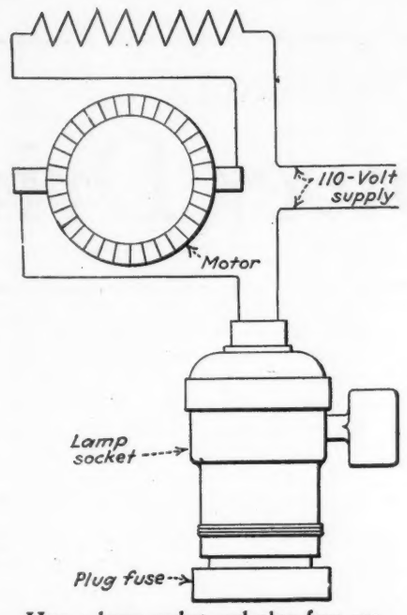
No doubt one large generator would have been better in regard to operating conditions, in view of future expansion, but on the other hand, the cost of a new machine was saved by placing into operation a piece of equipment that was lying idle. The exciter will always be ready in this location, however, to be put back into service on the alternator if it is ever decided to use it again.

H. G. MILLICAN.
Miami Electric Service Co.,
Miami, Fla.

Application of Lamp Socket as Emergency Switch

IT WAS necessary not long ago to connect a number of small motors for immediate service in a manufacturing plant. As these motors could be started without a resistance or a control device, nearly any two-pole switch would be suitable for this service. However, no switches were available, and as we could not wait for them to be ordered, the plant electrician decided to use lamp sockets instead of the ordinary starting equipment.

At first each socket was shorted with a brass strip fastened under the tongue of the socket, but later the strip was replaced by a fuse plug of the proper size, as shown in the accompanying illustration. In case of an overloaded or grounded motor, the plug fuse would blow and thus save the motor. After using various kinds of lamp sockets, it was found that a pull-chain socket shorted with a plug fuse made the most satisfactory emergency switch for this service.



How a lamp socket and plug fuse can be connected to control a 110-volt fractional horsepower motor.

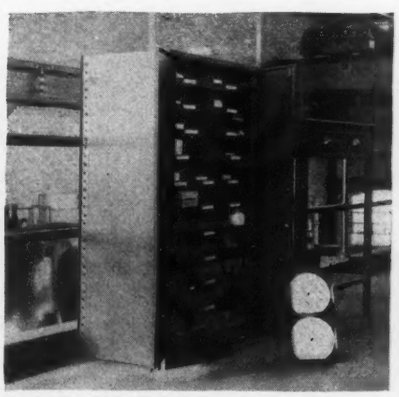
C. V. HULL.
Charles City, Iowa.

Convenient Method of Keeping Charts and Log Sheets

TWO handy all-steel cabinets are used by our company for filing recording charts and log sheets. The smaller one is located near the switchboard and the larger one is in the file clerk's office.

In the cabinet near the switchboard, which is shown in the accompanying illustration, a supply of charts and log sheets is always available. The shelves in the upper half of the cabinet, where the charts are stored, are two compartments deep. Each shelf in the lower half has but one section and one compartment in order to accommodate the large log sheets.

Charts and log sheets are kept in a steel filing cabinet, arranged as shown here.



For the purpose of keeping all charts neat and uniform in appearance, they are handled by the operator on the afternoon shift. The names of the engineer and the instrument on which the chart was used are stamped on each chart, several rubber stamps being supplied for this purpose.

In the larger cabinet in the file clerk's office all of the current year's log sheets and charts are kept together with those of the preceding year. This method of filing makes possible a quick and easy comparison of past and present operating data.

E. J. MORRISSEY.
Chief Electrician,
Western United Gas & Electric Co.,
Aurora, Ill.

Savings Effected by Changing Electric Light Fixtures

A NEW type of electric light fixture is being used throughout our plant because it is cheaper to operate and maintain than the old type. The old ceiling fixtures had a frosted glass reflector of the semi-indirect illumination type, which reflected approximately 40 per cent of the light against the ceiling. These old fixtures were installed in such a way that it was necessary for a man to climb up on steel girders and stand on an I-beam to pull a lamp fixture in where it could be cleaned and inspected. From 15 min. to ½ hr. was required to change a burned-out lamp and 40 min. or more was needed to clean the glass reflectors. This method of taking care of the lights was hazardous both for the repair man and for those who walked underneath the fixture while it was being cleaned.

Today all of the old fixtures have been replaced by Thompson safety switch lamps with an Ivanhoe, R.L.M., 18-in. reflector, which is designed to throw all the light downward.

Instead of 750-watt lamps, 500-watt lamps are being used. As about five lamps per fixture per year are used and as the cost of each lamp is $2 less than the 750-watt lamp there is a yearly saving of $10 per fixture. The reduction in size of each lamp, 250 watts, also makes a saving in current. As each lamp is operated on an average of 11 hr. a day, there is a saving of 1,004 kw.-hr. per year per lamp, at a cost of 1.5 cents per kilowatt-hour. This represents a saving of $15.05 in cost of current. Therefore, the savings per fixture per year amount to $25.05.

Now that it is no longer necessary to climb up on the I-beams for repairs or to replace lamps, because the fixtures can be lowered to the floor, considerable saving in labor may also be credited to the new fixtures. The net cost of installing the new fixtures was $31.10 per lamp. By comparing this figure with the saving credited to the new installation it is evident that the saving in a year nearly pays for the cost of the new fixtures.

E. J. ELVISH.
Maintenance Inspector,
Kaministiqua Power Co.,
Fort William, Ont., Can.

MECHANICAL MAINTENANCE OF *Power Drives*

This department will furnish mechanical details of installation, operation and maintenance of equipment in the path of power service from the first mechanical driving element through the auxiliary transmitting equipment to all driven machines.

Roller Chain Used on Quarter-Turn Drive

UNUSUAL operating conditions sometimes make it necessary to devise unusual drives. An interesting example of this kind may be found in the plant of the I. H. Dexter Co. of Goshen, N. Y.

This concern manufactures flexible shaft couplings consisting of tooth flanged members joined by roller chain of sufficient width to cover, between the side plates, the teeth cut in the periphery of both flanges.

The flanges on the large couplings are faced in a gap-lathe which was assembled in the shop. Because this machine is used but part of the time, nicety of design was sacrificed to utility and the lathe stands, rugged but inexpensive, a good tool for the purpose.

It is used as a facing lathe only and is fitted with a special cross slide. The power feed is unusual and presents some features of interest. The feed screw runs the full length of the table and has the usual ball crank for hand setting. Power is applied to this outer end from above.

A countershaft runs directly above and at right angles to the end of the screw and the extended cross slide, and advantage was taken of this fact to join the shafts by a chain drive. This is unique in that it connects the shafts at right angles which makes it a quarter-turn chain drive. Roller chain is used and is practicable because of the long centers and the slight flexibility in each link of the chain.

DONALD A. HAMPSON.
Plant Superintendent,
Morgans & Wilcox Manufacturing Co.,
Middletown, N. Y.

Construction of Scraper for Cleaning Oil and Dust from Shafts

ACCUMULATIONS of dust and grease often make it necessary to scrape lineshafts from time to time in certain types of plants. A novel scraper for this purpose is shown in the accompanying drawing. This scraper is so made that it can be adjusted to suit shafts of various diameters. The eight scraping edges can be used a long time between sharpenings. The edge in use lines up square and lies flat on the shaft even though the handle is held out of vertical.

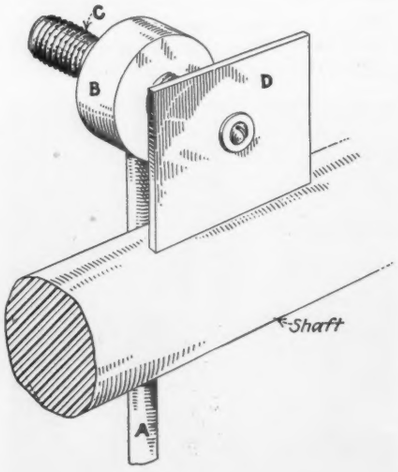
The handle *A* is of a length which enables it to be held from the floor. The handle is threaded at one end to fit into the collar *B* which is tapped in the center to take the scraper-holding-screw *C*. The scraper *D* is held in place by a screw and washer in the end of *C*. To operate this device the screw *C* is turned in or out of the collar *B* until the scraper *D* extends just past the center of the shaft to be cleaned, as shown. The operator stands on the off side of the shaft so that the rotation of the shaft is toward the scraping edge and pulls down slightly on the handle as he walks along the length of the shaft. If it would be objectionable for the scrapings to fall on the floor or machinery a basket arrangement could be placed on the handle *A* to catch the scrapings as they fall.

Although the scraper is hardened it does not cut into the shaft while cleaning it. However, merely scraping off the dirt soon tends to round the edge and the value of the eight scraping edges will be apparent. It is only necessary to remove the small screw and washer which holds the scraper *D* and turn the scraper over to get the second four edges. The edges are ground flat, as on a wood scraper, and a pull on the handle *A* brings the blade parallel and flat on the moving shaft.

HAMILTON, ONTARIO, CAN. H. MOORE.

Easily constructed device for scraping moving shafts.

Where accumulations of dust and oil on a shaft are undesirable, a scraper, such as this, handled from the floor, will quickly clean the moving shaft without danger to the operator. The scraper is adjustable to shafts of different diameters by turning *C* in or out of the collar *B*. The scraper can be set to the proper shaft diameter by measurement before placing on the shaft.



Precautions to Take When Using White Metal for Rebabbitting Bearings

THE rebabbitting and fitting of white metal bearings is one type of work which is largely dependent on the mechanic's skill and even the best mechanics fail occasionally. One of the principal pitfalls in this work lies in the delicate and unstable chemical composition of the white metal itself. If the metal is not carefully treated in heating and pouring, although the bearing may be poured successfully, the resultant bearing surface may not have the wearing qualities expected.

White metal is not the same as other bearing alloys, as the terms are generally understood. If the surface of the white metal is examined under a microscope, a number of hard crystals are shown immersed in a plastic material, much in the same manner as hard stones are immersed in a plastic tar compound in some of the road building materials. When installed in a bearing the journal presses on the bearing surface and the load is carried on the hard crystals; however, the plastic material yields and allows the load to be distributed evenly over the whole surface. This, at least, is what should happen in practice but, unfortunately, a good texture of metal is difficult to form and easy to damage.

Every white metal alloy has a critical temperature and, if it be heated much above this point, oxidation of the metals occur; this may lead to the inclusion of undesirable oxides in the poured metal itself. Metal oxides are hard, tin oxide approaches the hardness of hardened steel; if this oxide is on the bearing surface the result will be increased friction and overheating and it is also possible to slightly score the shaft. If the metal has been overheated a careful stirring as it cools down will remove, at least partially, the ill effects.

Molten white metal should always be kept well stirred; otherwise, its va-

rious constituents will not be uniformly distributed throughout its whole mass. The rate at which the bearing is cooled off after pouring is important; too rapid cooling results in a partial or complete prevention of the separation of the hard particles. These compounds remain partly dissolved and even if and when they do segregate, their size remains small. Too slow or retarded cooling causes excessive growth of the harder constituents and a general coarsening of the microstructure; this embrittles the surface.

The rapidity of the cooling process is partly dependent on the pouring temperature, the temperature of the shell and mandrel, and, also, on the surrounding atmospheric temperature. If the pouring is done in a cold and exposed position, cooling will be rapid; if done in a hot room, such as a furnace room or foundry, cooling will be slow. The bearing shell should be heated before pouring, and the atmospheric temperature should be moderate; the observation of these conditions should help to obtain satisfactory results.

In all babbitting of bearings it is important that the shell be thoroughly cleaned and tinned before pouring; otherwise, the metal may not make a tight joint with the inside of the shell and shrink away when cooled. Also, with a solid union of the metal to the shell any heat generated between the shaft and the bearing will be conducted through the white metal to the shell and thence to the metal supports and dissipated by the large radiating surface. If the cleaning and tinning of the shell is not carried out properly, even assuming that the lining is securely fixed to the shell mechanically, the thermal conductivity will be bad and heat will not be transmitted between the white metal and the shell as it should be.

Shefford, Bedfordshire, England. W. E. WARNER.

Mounting Power Transmission Equipment Overhead from Special Steel Shapes

THE cost of erection of groundwork for mounting overhead equipment often seems quite high but an investigation shows that this is usually due to some structural conditions within the new building or extension. This is especially so when the building was not designed primarily for ease in mounting such overhead equipment. When such is the case, a considerable amount of extra millwright work is needed to provide groundwork for supporting the structural steel or wooden stringers to which the overhead equipment is attached. Millwright labor is high and because of its nature cannot be rushed. In some instances, this cost of erection has had a deterrent effect on the selection of lineshaft drives as opposed to direct motor-driven machines.

Plant engineers have found that the use of special steel shapes for the support of overhead machinery helps to keep this cost down. These shapes provide a flexibility in arrangement which cannot be obtained with wooden or standard steel shapes. Also, these special shapes can be installed very easily in any industrial building, whether the structure is of concrete, of brick and steel, or of the mill type. Figs. 1, 2 and 3 show applications of these steel stringers.

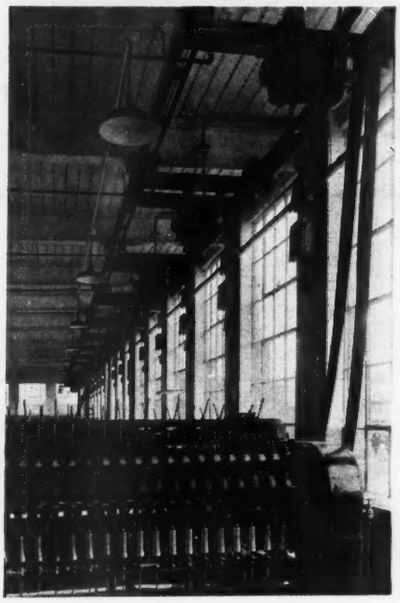


Fig. 3—Framework for mounting a line of fifteen motors.

Four men put up this steel groundwork and installed the line of fifteen 10-hp. motors in a day. The motor slides are mounted directly on the short cross-stringers and so provide for lateral adjustment to take care of belt stretch. Compare the cost and convenience of this method of mounting with that incidental to the erection of overhead platforms for the motors.

Many industrial operating men have a decided preference for placing motors, even up to 20 or 30 hp., on the ceiling. They also prefer to have them erected in what has always been considered the normal position, and therefore they construct platforms suspended from above, for mounting the motors. A motor, however, will run just as well upside down. There seems to be a growing tendency to dispense with the platform and attach the motors to the stringers in the reverse position. Fig. 3 shows a line of 10-hp. motors suspended in this manner from steel stringers in a large yarn mill. Steel stringers lend themselves to this sort of an installation just as well as to the mounting of lineshaft and countershaft hangers, as shown in Figs. 1 and 2. The stringers and motors shown in the illustration, Fig. 3, were set up in one day by four men. If necessary, this complete installation can be moved to another location or the units shifted slightly with very little time and trouble.

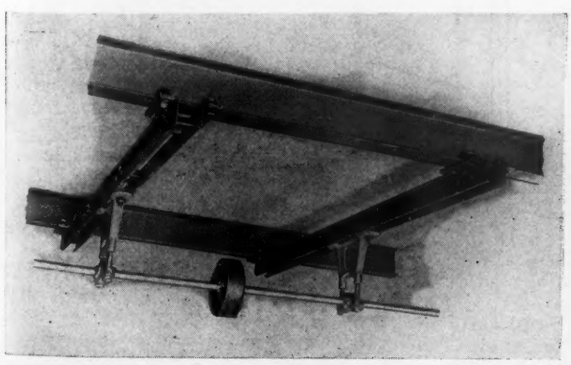
This steel stringer equipment effects a considerable saving in the erection of overhead equipment and greatly reduces the cost, in contrast to direct motor drives.

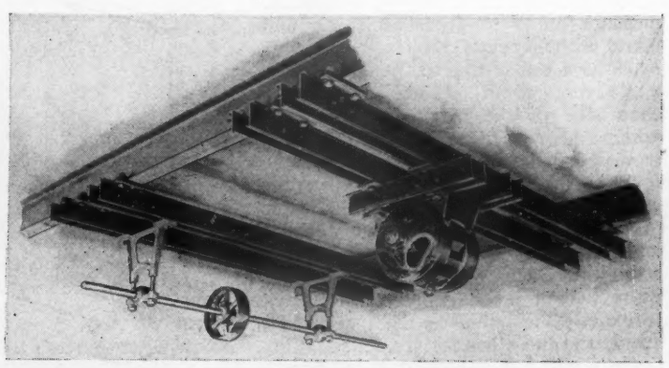
The extreme flexibility afforded by the use of these steel shapes, which are standard for all purposes of supporting equipment, greatly facilitates the machinery arrangement, particularly for new buildings. Irrespective of the relative position decided upon for the machinery, the line- and countershafting can be economically erected in the desired location under all building conditions. The necessity for making an elaborate transmission layout in the draftingroom beforehand is eliminated, although a rough layout is always desirable.

P. L. PRYIBIL.
Vice-President,
Midwest Steel & Supply Co.,
Bradford, Pa.

Figs. 1 and 2—Methods of mounting overhead transmission by using special steel stringers.

These two illustrations show how Midwest steel stringers are used for mounting shafting and motors to the steel I-beam ceiling structure. In one case the lineshaft is mounted parallel to the I-beams and in the other at right angles. The ease of erection and convenience of moving are two of the advantages of this style of structure.





In the Repair Shop

This section is devoted to repair work on electrical and mechanical equipment. Special attention is given to shop or bench tools and short cuts or improved methods of handling work of this character. Contributions are always welcome.

Life of Bearings Increased by Individual Fit

IT IS a well-known fact that in most industrial plants more bearings are burned out from lack of lubrication than from ordinary wear. For this reason it is necessary to keep spare bearings in stock for motors on all important drives. These stock bearings can be used satisfactorily on new motors that have had reasonable care, but for all general purposes an individual fit should be given to each set of bearings, if long life is to be expected.

The responsibility for this important work should not be assumed by anyone or delegated to anyone other than a capable machinist who understands the principles involved. The time and money required to fit bearings properly are well spent in promoting higher efficiency and operating economy in the plant. The reliability of power drive equipment depends to a large extent on the condition of the bearings.

Birmingham, Ala. G. H. EMERSON.

How to Construct Handy Shelves For Shop Purposes

THE FACT that it is easy to nail a few boards together and pass them off as a shelf or rack probably accounts for most attempts at economy in the shop. If the matter of shelves or racks has been neglected or their purchase in the open market disapproved, a very cheap and durable shelf can be easily constructed in a short time. The material needed consists of angle iron and sheet iron, with some bolts and nuts, and the necessary tools.

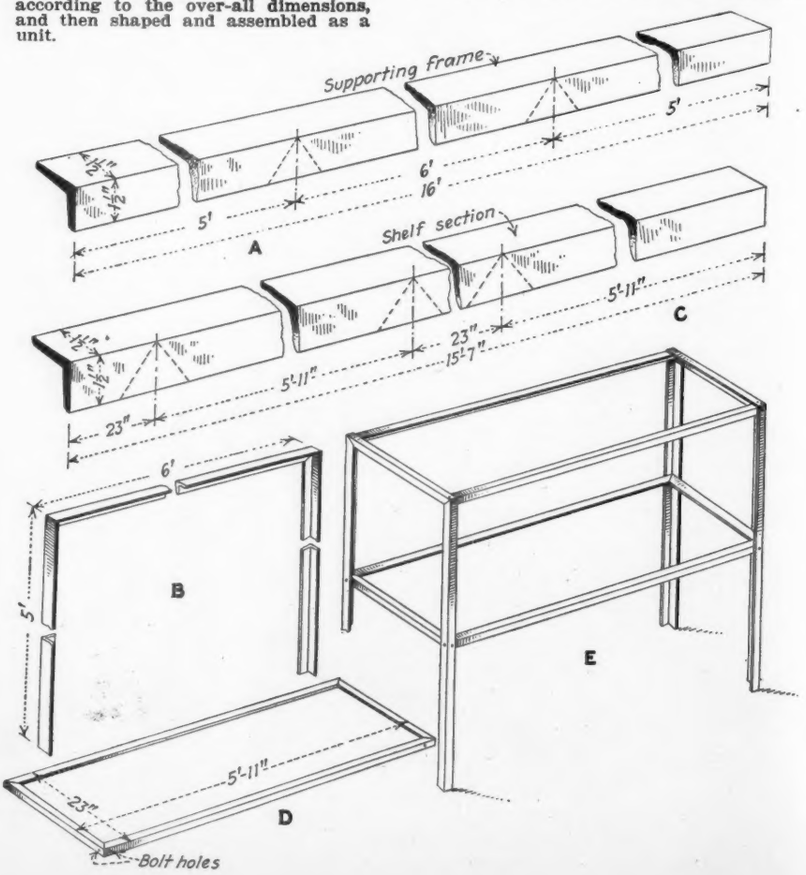
In laying out the shelf, first determine the length and height desired. If the height is assumed as 5 ft. and the length 6 ft., it would be logical to order angle iron 16-ft. long to avoid cutting. I have found that angle iron 1½ in. wide may be used for most purposes. On a 16-ft. length as shown at *A* in the illustration, measure off 5 ft. from each end and mark with a center punch. With this mark as a center line to the edge of the angle iron, cut out a 45-deg. wedge from each side of the mark. When these notches are cut in one side of the angle iron, it can be bent to shape the frame for the shelf, as shown at *B*. If the cuts in the angle iron have been made properly, they will fit when bent to shape and then may be welded together for strength. Each section of shelf will require two of these angle-iron units cut to exactly the same length—one for the front, and the other for the rear section.

On a unit 5 ft. high and 24 in. deep, I have found two shelves practicable for most purposes. The frame *C* for the shelf surface is laid out in the same manner as the supporting frame, and after preparation it is bent to shape as at *D*, with holes already drilled in the angle iron for the bolts. The assembly of the unit *E* follows, in which the front and rear supports are then bolted to angle-iron spacers of the same size and so arranged that the supporting spacer is used to form a natural shelf support. The shelf may consist of an ordinary piece of sheet iron, but where heavy materials must be supported, ¼-in. steel with a center brace is recommended.

Chief Electrician, E. J. MORRISSEY.
Western United Gas & Electric Co.
Aurora, Ill.

A simple method of fabricating angle-iron shelf units.

The supporting members of the frame and the shelf surface are laid out according to the over-all dimensions, and then shaped and assembled as a unit.



Principal Factors Involved in Changing a Motor From Two to Three Phase

A PROBLEM was given me a short time ago concerning the reconnecting of a 5-hp., 220-volt, 60-cycle, Type C.C.L., 24-coil Westinghouse motor, connected two-path, two-phase, four-wire, for three-phase, 220-volt, 60-cycle operation.

This motor can be reconnected for 220 volts, three-phase, by cutting out approximately 20 per cent of the turns. The method of arriving at this conclusion is as follows:

The first step in changing from two to three phases is to find out what the series-delta line voltage would be, and next determine the line voltage with a series-star connection. Then select the most suitable connection from this combination.

The formula for changing from two- to three-phase, series-delta line voltage would be $C \times V \times 0.7$, where C is the number of paths or circuits in the two-phase winding, and V the two-phase line voltage. The series-star line voltage is found with the following

formula: C × V × 1.21, where C and V have the same meaning as used initially.

Then the three-phase series-delta line voltage should be 2 × 220 × 0.7 = 308 volts. The series-star line voltage would be 2 × 220 × 1.21 = 532.4 volts.

As 220 volts and three-phase operation is required, the best connection is a two-parallel star, which means that the line voltage should be 532.4 ÷ 2 = 266.2. This is 21 per cent higher than the line voltage obtainable under normal operating conditions for standard equipment.

To make the change there are two things that can be done: First, rewind the stator, reducing the turns per coil to 80 per cent of the present turns and increase the cross sectional area of copper 20 per cent. Second, regroup the coils for three phase and arrange the coils per group so that the phase insulation is satisfactory, that is, provide one coil at the end of each pole-phase group with additional insulation and cut out 20 per cent of the coils, which, in this case means that 24 × 0.80 = 19 active coils will be left in. But as 19 is not divisible by 3, the number of phases, an active number of coils must be selected that will give an equal number of coils in each phase and also permit uniform odd grouping.

If the motor in question had four poles there would be 12 pole-phase groups, and as a two-parallel connection is required, the number of coils in each parallel circuit or leg must be equal in number. Therefore, in this case, the number of active coils would have to be 18 for either a four- or six-pole motor, which means cutting out six coils.

Cutting out the coils does not mean that the rating should be reduced, as the coils or turns cut out are excessive and are not needed to develop the required line voltage. But what is more important is the current carrying capacity of the wire on the two-phase coils as the current per terminal for a three-phase motor is approximately 15.5 per cent higher than for the corresponding two-phase motor.

Thus, cutting out the turns does not alter the horsepower rating but does effect the I^2R losses and the final efficiency and power factor. The three-phase rating will then depend upon the design of the motor in question, that is, if the design is liberal, the horsepower rating with the three-phase grouping can be higher than where the design is close.

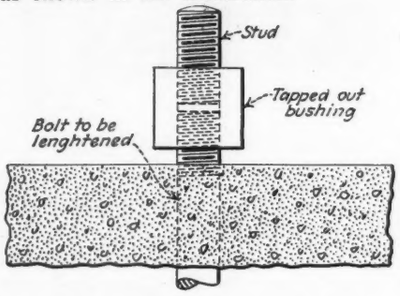
The efficiency and horsepower at the reduced rating should be slightly higher when coils are cut out, the amount depending on the design and other factors. But, when the turns and size of wire are altered correctly, then both ratings should be alike.

This subject is covered in more detail in Mr. A. M. Dudley's book, "Connecting Induction Motors," second edition.

A. C. Roe.
Renewal Parts Engineering Dept.
Westinghouse Electric & Mfg. Co.,
Homewood, Pa.

Bushing Method of Lengthening Anchor Bolts

NOT long ago it was necessary for us to raise a machine several inches above its original position due to changes made in the gearing. We were at a loss for a while to know just how we could use the same foundation bolts, which were too short after the machine had been raised. After considering putting in new bolts, it was decided to make a bushing connection as shown in the illustration.



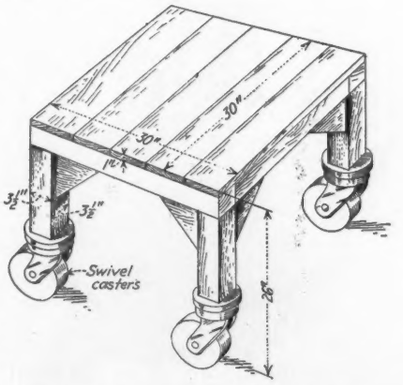
The old foundation bolts were lengthened by screwing steel bushings over them and then screwing stud bolts into the bushings.

We tapped steel bushings to the size of the bolts and screwed them down halfway on the original foundation bolts. Stud bolts were then made to correspond to the difference in length and these were screwed into the bushings, making the original foundation bolts the required length. The machine was set on the new foundation and put into service immediately. Considerable time was saved with this method, and we feel certain that it is a first-class job.

Denver, Colo. R. M. Thomas.

Bench Truck for Transporting or Repairing Motors

A FACTORY that is motor driven throughout has made the bench truck shown in the accompanying illustration, to transport the motors about as needed and for use as a temporary work bench. The plant has nearly a hundred a. c. motors of 2½- to 15-hp. rating in use and some spares.



This bench truck is used for transporting or for supporting motors while making repairs.

Sometimes the work to be done consists of nothing more than putting in a duplicate bearing or cleaning out a dirty oil well, but the location of the drive is such that the work can be better done with the motor up where there is sufficient light and working space. It has been found that time is saved by loosening the four bolts holding the motor, disconnecting the coupling, and getting the motor in a convenient position, rather than by attempting to do the work in a dark and limited space. Also, when the motor is up where it can be examined carefully, it can be cleaned more easily and worn insulation, or other defects which would be likely to cause trouble later, are often found, although they may not have been noticed on the preliminary examination in the darker or more inconvenient location.

In addition, this truck is used to transport the motor when it has to go to the shop for more extensive repairs. An advantage here is that the truck belongs to the maintenance department and so can be used without interfering with production work. The truck is substantially constructed and has No. 190-L Payson swivel casters under it, which, combined with its relatively small size, enables it to be pushed around easily and into places where other trucking or loading equipment would not go. When in the shop the motor may be repaired while on the truck, if no other motor is down, and its size and height lend themselves to convenient working.

The factory's woodworking department turned out this truck. The legs and rails are made of maple and a 1-in. maple floor is laid on top. Carriage bolts (not shown) were placed diagonally at the corners and braces added for further stiffness. Use has demonstrated that the truck was built for rough service and it has more than earned its cost.

Donald A. Hampson.
Plant Superintendent,
Morgans & Wilcox Mfg. Co.,
Middletown, N. Y.

Wooden Case for Protecting a Pocket Compass

MOST electricians have in their tool kits a pocket compass which, due to its delicate construction, is very likely to be damaged if not protected. A compass case can be easily made, which will prevent damage to the instrument, and yet permit its use while it is so inclosed.

To build this case it is necessary only to bore out a block of wood so that the compass just fits into the case snugly. The block is then cut down so that there is a wall of wood approximately ½ in. thick around the compass. A cover which is so made that it can be turned to expose the compass dial will serve to finish up the case. It is not necessary to remove the compass from its case in order to observe the needle; so any danger of injuring the compass is very remote.

Chas. A. Peterson.
Chief Electrician,
Fairbanks Exploration Co.,
Fairbanks, Alaska.

New Equipment

for plant operation and maintenance

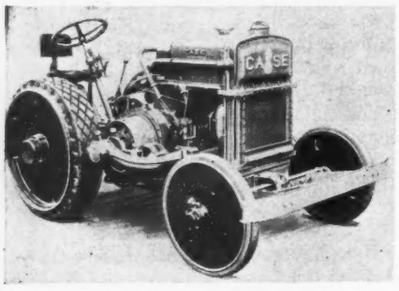
Industrial plant executives concerned with the selection and operation of mechanical and electrical equipment will be interested in these new devices which are designed to improve plant operation or reduce operating and maintenance costs.

Industrial Tractor

AN ANNOUNCEMENT has been made by the J. I. Case T.M. Co., Racine, Wis., of their new industrial tractor, intended for use in factories, railroad shops, freight terminals, oil fields, lumber yards, road building and maintenance work, parks, logging camps, and elsewhere.

Because much of the work of such a tractor is in close quarters, this machine is built compact and low. Also, the great stability claimed for this tractor is due principally to its low center of gravity.

A radius of only 10 ft. is needed to turn the machine around completely and a quick-acting throttling governor regulates the speed of the engine.



Case Industrial Tractor

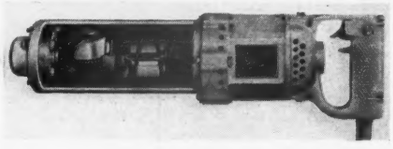
The weight of the tractor is so distributed that approximately two thirds of it is borne by the rear wheels. These wheels are cast hollow so that, if necessary in very hard going, they can be filled with 400 to 500 lb. of sand for additional traction.

Portable Electric Hammer

THE ACCOMPANYING sectional view shows the internal mechanism of the new electric hammer announced by Black & Decker Mfg. Co., Towson, Md. The universal motor in this hammer is of the same type as used in the Black & Decker portable electric drills, with the exception of a few minor refinements that make it more applicable for this particular type of work. The motor armature turns at approximately 10,500 r.p.m. and is equipped with an aluminum centrifugal fan. Automatically adjusted ball bearings are used on the armature shaft.

The armature-shaft is hollow to accommodate the spline-shaft upon which the reciprocating hammer mechanism is mounted. This reciprocating mechanism, which actually strikes the blow, is made up of a drop forging upon which are mounted the two beveled gears heavily weighted on one-half of their area. These gears are driven by a beveled pinion on the spline-shaft and rotate in opposite directions. When the two weights are together at the bottom, the reciprocating mechanism moves downward, striking a heavy blow on the oil-tight piston which transmits the blow to the drill or cutting tool. When the two weights come around together at the top, the reciprocating mechanism travels up with equal force, but the blow is absorbed by the coil spring.

The hammer strikes 2,300 blows per min. The working mechanism operates in a bath of oil and is, therefore, sealed against dust and grit.



Black & Decker Electric Hammer

Electric Hoists

AN ALL-STEEL, quarter-ton electric hoist, adaptable for quick-lift service, has been put on the market by the American Engineering Co., Philadelphia, Pa.

This high-speed hoist has a pressed-steel frame with gears and shafts of chrome-manganese steel. In addition to the ball bearings and the non-spinning hoisting rope features, dependable service is made possible by the oil bath lubrication. All working parts are fully inclosed and the hoist is operated by a push-button control and upper and lower limit switches.

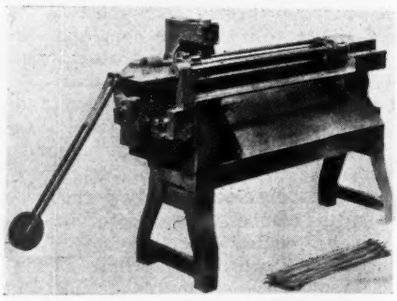
The hoist weighs 200 lb. and is made in two types—plain trolley and hook suspension. The plain trolley type requires 16 in. headroom and the hook suspension type 18 in.

American Engineering Co. High-Speed Hoist

Wire Cutter and Stripper

A NEW type of machine, which automatically measures wires into lengths, cuts them off and simultaneously strips the insulation from both ends, has recently been developed by the Artos Engineering Co., 69 Wisconsin St., Milwaukee, Wisc.

This machine is adjustable in regard to cutting lengths, stripping lengths, and size of wire. As it is claimed the capacity of the machine is very large, 3,600 pieces being cut and stripped per hour. Several operations are combined into one, thereby resulting in a considerable saving in labor.



Artos Automatic Wire-Cutting and Stripping Machine

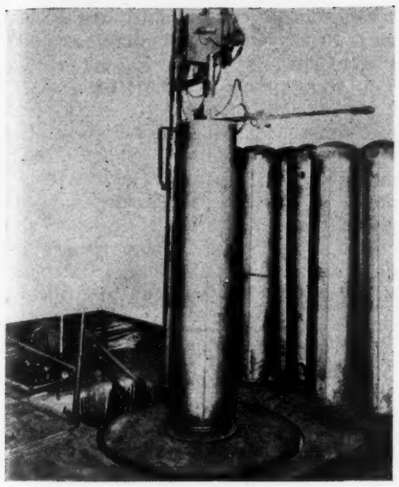
Automatic Welding Device

A NEW carbon arc-welding machine has just been placed on the market by the Lincoln Electric Co., Cleveland, Ohio. This equipment is designed for the purpose of welding bottom seams on cylindrical tanks.

The equipment is standardized for tanks up to 6 ft. in diameter and 8 ft. high, but special equipment may be furnished to handle any diameter or length of tank.

It is claimed that on 14-gage material a lap head seam, as shown on the tanks in the illustration, which have been welded, can be welded at the rate of 135 ft. per hour. Also, the edge weld used on the bottom of some types of range boilers may be welded at the rate of 150 ft. per hour, as the bottom is flanged and fitted so that the edges are together and flush with each other.

Tanks that are to have the bottom seams welded are set on a revolving table and the arm carrying the automatic welding head is adjusted to bring the arc on the seam. The spread of the revolving table is adjustable over a wide range to handle various sizes of tanks, and the welding current is also



Lincoln Automatic Bottom Welder for Cylindrical Tanks

adjustable through the controls located on the welder control panel. An automatic stop and start control on the automatic welder head is provided for the operator.

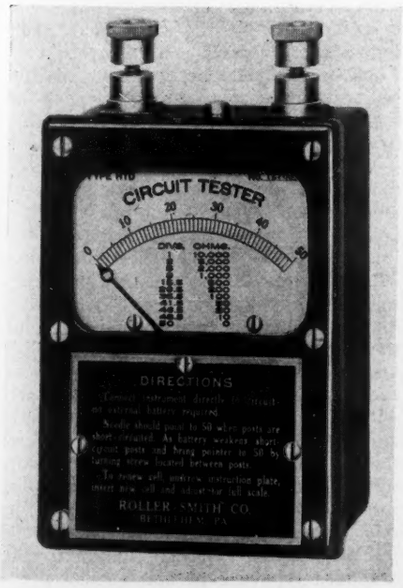
Circuit Tester

A PORTABLE, direct-reading circuit tester, known as Type HTD, has been put on the market by the Roller-Smith Co., 233 Broadway, New York, N. Y. The uses of this instrument are twofold. It can be used to ascertain if there is an electrical circuit existing between conductors applied to the terminals of the instrument and it can also be used to obtain an approximate idea of the resistance of the circuit under test.

A small D'Arvsonal type d.c. voltmeter is used in series with a standard flashlight battery 1 in. in diameter by 2 in. long. The instrument pointer will indicate full scale when the terminals are short-circuited. The scale is divided into 50 uniform divisions of arbitrary value. Directly below the scale is located a chart, by reference to which resistances up to 10,000 ohms may be calculated.

By removing three screws the instrument plate can be taken off and the dry cell replaced. The removal of this plate also gives access to the internal zero adjustment. The instrument weighs 19 oz. and is inclosed in a heavy sheet-metal case with black finish, which measures 4½x3x1½ in.

Roller-Smith Type HTD Portable Circuit Tester



Push-Button Station

ANNOUNCEMENT has been made by the General Electric Co., Schenectady, N. Y., of a new push-button station for use in preventing the cutting out of motors controlled by a magnetic starter when there is a brief power disturbance. The station has two push buttons, "Start" and "Stop," and bears the G.E. designation CR-2940-BS-82-A.

The station is used with standard magnetic starters, making it unnecessary to add time-delay attachments to the starters themselves. When power fails the magnetic starter will, of course, drop out but will reclose upon the return of voltage by the action of the push-button device, unless the time for which the push-button station is set is exceeded, when the "Start" button must be pushed to energize the magnetic starter and restart the motor.

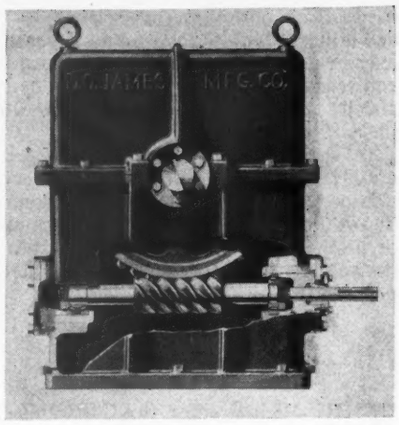
When the voltage drops sufficiently to permit the solenoid to release the plunger, the latter starts to fall, but is retarded in its downward movement by a rack which turns a gear. The gear engages a ratchet, which can be adjusted for a maximum of 1.5 sec. by means of a heavy nut at the end of a rod which serves as a pendulum.

If power does not return before the expiration of the time limit for which the device is set, the contacts will open and both the solenoid and magnetic starter will be disconnected until the "Start" button is again pushed.

Speed Reducers

THE NEW James heavy-duty worm-gear speed reducer, as illustrated, has been put on the market by the D. O. James Manufacturing Co., 1114 W. Monroe St., Chicago, Ill.

In this speed reducer, phosphor bronze gears, chrome nickel steel worms, Timken and Norma Hoffman roller bearings and interchangeable bushings are used. A lock nut and lock pin, which allow for easy adjustment, hold the thrust bearing in proper position on the worm shaft. A large heat radiating and oil cooling space in the housing keeps the oil at a low temperature, it is claimed, and the stuffing gland and the worm shaft can be easily replaced.



James Heavy-Duty Worm-Gear Speed Reducer

The housing is made of gray iron, designed for maximum oil cooling space, and braced on the outside for strength.

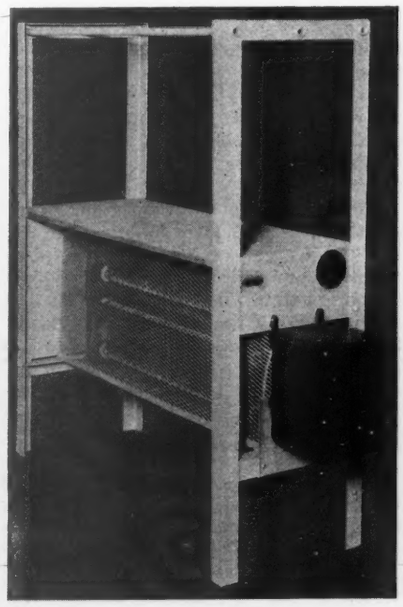
Electric Heaters

ANNOUNCEMENT of electric change-house heaters for use in the oil and mining fields and for use in building and construction work has been made by the Westinghouse Electric and Manufacturing Co., at Mansfield, Ohio.

These type HA heaters consist of an angle-iron and sheet-metal frame, two oven heaters being suspended under the shelf and protected by an expanded metal screen. A rack at the top is useful for holding clothing while drying, and the shelf may be used to warm lunches or for other purposes.

An oil-immersed switch is used for turning the power off and on, for ordinary applications where oil switches are not required, a WK-62 safety switch is

Westinghouse Type HA Electric Change-House Heater



used. The power required is 10 kw., and either 220 or 440 volts, single phase, may be used. The apparatus is strongly constructed and weighs slightly over 100 lb. The overall dimensions are 18 in. x 50 in. x 50 in. high.

In special cases where warm water must be supplied, cast water coils are clamped on either side of the heaters. These will furnish a considerable amount of heated water and the stored heat in the castings is sufficient to warm water passing through the coils.

Push-Button Starters

THE Allen-Bradley Co., Milwaukee, Wis., has placed on the market a complete line of a.c. and d.c. push-button starters ranging from ¼ hp. to 10 hp., 220 volts, d.c. and 15 hp., 550 volts, a.c.

The a.c. and d.c. switches of similar rating have the same external dimensions. The covers on all starters swing to the side, and can be locked against tampering and injury to any employee

Allen-Bradley A.C. Push-Button Starter

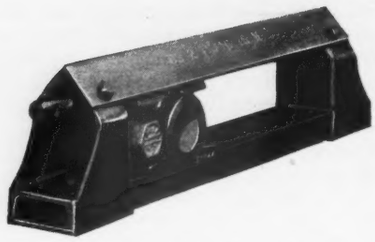
not authorized to open the box. All parts of the switch are readily accessible for inspection and ample room is provided for wiring.

The a.c. starters give protection against overload, no-voltage, and single-phase operation. An outside reset lever makes resetting of the inducto-therm relays convenient. Arc shields are used on all switches and magnetic blow-outs on the larger sizes of both a.c. and d.c. switches.

The d.c. starters, it is claimed, give positive starting, no-voltage, and overload protection. A special graphite compression register gives stepless acceleration until all resistance is cut out at full speed of the motor. The resisto-therm relays are designed to give accurate overload protection.

Protected Screw Type Take-Up

IMPROVED design of the protected screw type take-up for heavy work and long-movement, to be known as Style DS, has been announced by the Link-Belt Co., 300 West Pershing Road, Chicago, Ill. Its details of construction and design conform with sound engineering practice, it is stated.



Link-Belt Style DS Protected Screw Take-Up

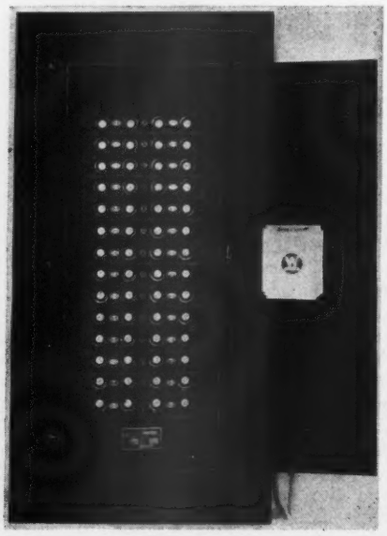
The frame is of welded structural steel with channel base welded to ends formed of steel plates, bent and welded into strong box members and in which the adjusting screw is mounted. The steel angle bolted on top of the ends protects the screw from dirt or the weather, in addition to tying the ends together, thus strengthening the frame and preventing upward movement of bearings. This feature is shown in the accompanying illustration. The protected screw remains fixed in position, and the nut for adjusting the movement of the bearing travels on the screw. The movement-adjusting screw does not project beyond the ends of the frame. The cast-iron bearing is lined with babbitt, is tapped for grease cup or pressure fitting, and is proportioned in length for each diameter of shaft, it is stated.

Plug-Fuse Type Panelboard

TWO new types of panelboards that are small, compact, and of the plug-fuse, full-safety type, have been introduced by the Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

These two new panelboards, known as Types JF and NJF, are built up of individual sections of black molded composition. Each section or block consists of eight plug fuse receptacles

New Westinghouse Panelboard of the Plug-Fuse Type



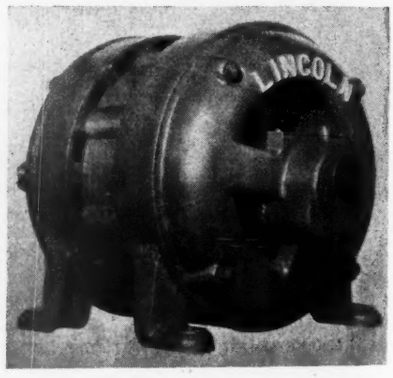
arranged for four circuits, double fusing, Type JF, or for eight circuits, single fusing, Type NJF.

Main switches are of the rotary-brush contact type with quick-break mechanism breaking the current at two points. The handle of the switch is mounted on a cast faceplate. Adjustment of the panel and trim is accomplished by means of the adjustable corner irons and the Westinghouse indicating trim clamp. Any adjustment within a limit of ¾ in. can be made.

Welded Steel Motor Frames

WELDED steel motor frames are now claimed as a feature of the new motors manufactured by the Lincoln Electric Co., Cleveland, Ohio.

The construction of the new motors is an assembly of hot rolled steel parts welded into the equivalent of a casting. It is claimed that the welded steel method of construction gives a practically unbreakable frame, lighter weight and better ventilation.



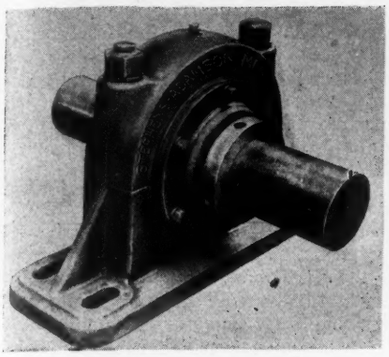
Lincoln Electric Welded Steel Motor Frame

Roller Bearings

A NEW bearing, called the super-service bearing, which is equipped with Hyatt anti-friction rollers, is manufactured by the Stephens-Adamson Manufacturing Co., Aurora, Ill. These journals are designed for bearing service where heavy loads are to be carried and where economy is of particular importance.

With these bearings two types of mountings are employed—the standard and adapter types. In the standard type, the shaft is turned to receive the inner race, which is pressed into place. The shaft may extend beyond the bearing through the housing cover at a diameter slightly smaller than that for the inner race, or it may be cut off and a closed cover used. The outer race is pressed into a spherical shell which is allowed to oscillate in a spherical seat in the base to correct any slight misalignment of the shaft. A plain annular collar is provided inside the roller inclosure for moderate thrust loads in one direction.

The adapter type is similar to the standard type except that special prep-



Heavy-Duty Stephens-Adamson Bearing

aration of the shaft is avoided by using an inner race bored to slip onto commercial stock shafting of the same diameter as the maximum extension for the standard type. The inner race is held in position and prevented from turning by two set-screwed collars engaging the ends of the race and extending through the housing covers to make the set screws accessible without disassembling. The closed cover cannot be used with the adapter type. The adapter bearing is especially applicable to interior locations on long shafts and as a replacement for plain bearings on old work.

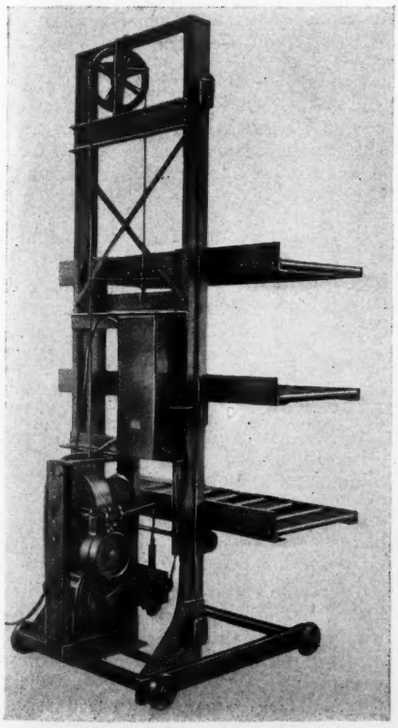
Stacker with Roller Conveyor

CONSTRUCTION of a stacker that can be adapted generally in plants using roller conveyor systems has been announced by the Lewis-Shepard Co., Watertown Station, Boston, Mass. The platform of this stacker, as is shown in the accompanying illustration, is constructed with rollers similar to those used on conveyors. The stacker is used to bridge gaps where conveyors are on various levels, for elevating materials from, or lowering to, the floor, or for transferring material from one conveyor line to another where conveyors are on parallel levels, it is stated.

The stacker can be powered with motors varying from ½- to 3-hp. rating. The unit is driven by an inclosed worm running in oil. The slacker is portable and is constructed of arc-welded structural steel.

This company has also developed a small hand power stacker for use in elevating heavy apparatus such as motors, heavy controllers, or other electrical equipment for mounting or removing from walls or machines, or holding in position while attaching.

Lewis-Shepard Stacker with Roller Conveyor Platforms



Flexible Coupling

IMPROVED lubrication features have been added to the flexible coupling manufactured by the W. H. Nicholson & Co., Wilkes Barre, Pa. Previous announcement of this unit was made on page 42 of the January, 1927, issue of INDUSTRIAL ENGINEER. The coupling consists of two hubs on flanges keyed to the shaft. These flanges are connected by loose keys in the outer edge of the flanges. The entire coupling is incased in a two-piece shell.

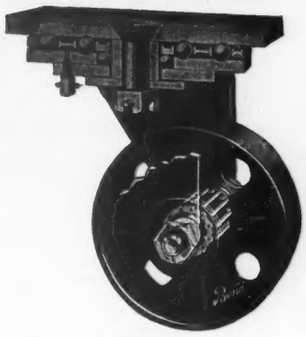
The improvement consists of holes that are drilled longitudinally through the floating keys and the hubs or flanges. These holes serve as reservoirs for oil. In addition, a lip is now extended from this casing over the left hub of the coupling and oil can be poured into this lip either while the coupling is idle or in motion.

With the added space provided by the holes in the lip, the coupling is said to carry approximately 150 per cent more oil than the older type. The improved type is known as Style A, and the old type without the oil lip is designated as Style B.

Swivel Truck Caster

IN THE new Ajax swivel truck caster illustrated, which has been placed on the market by Bond Foundry & Machine Co., Manheim, Pa., three sets of ball bearings are provided in the caster. In the 8-in. caster, for example, a machined ball race with 16 steel balls is set near the pin to take the radial load when swiveling.

In addition, two machined ball race grooves take the load and assist in making swiveling easy. The outer race has 24, and the inner race 13, ⅝-in. chrome steel balls. The wheel revolves on solid steel rollers spaced by a steel retainer. The caster is made with 6-in. or 8-in. wheels. Either Alemite lubrication or an automatic oiling wheel, which is provided with an oil reservoir with a felt oiler, may be obtained.



Bond Ball and Roller Bearing Swivel Truck Caster

The manufacturer states that this is practically an all steel caster; the caster except for the semi-steel wheels is of open-hearth steel.

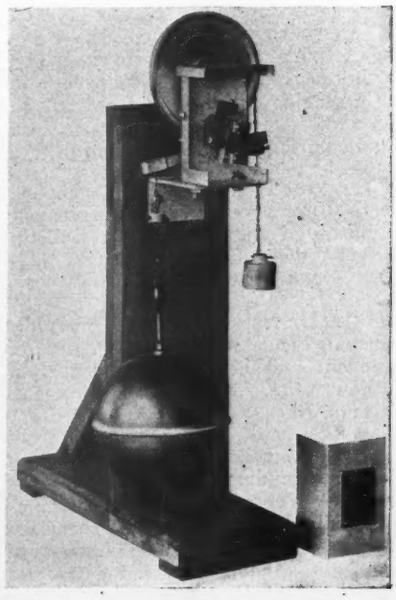
Float Switch

ANNOUNCEMENT has been made by the General Electric Co., Schenectary, N. Y., of a new float switch bearing the designation CR-2931-P, for use in control circuits only. This switch, in general, will be used to control the line contactor of alternating or direct-current automatic starters. It has a capacity for handling one 600-amp., two 300-amp. or four 150-amp. a.c., or d.c. contactors at from 110 to 550 volts.

A very simple design is employed. No castings are used, and a double contact eliminates shunts. It is claimed oxidation trouble has been eliminated by the use of silver contacts. The contacts are held by a moulded Bakelite arm that obtains its snap action in opening and closing the switch through a special mechanism.

The switch may be attached directly to a support extending across the tank or by means of a suitable side bracket.

G.E. Float Switch



Trade Literature

you should know about

Copies of literature which is described on this page can be obtained by writing to the manufacturer whose name and address are mentioned. It is always advisable to state the name and number of bulletin or catalog desired, as given in these columns.

GREASE LUBRICATION—A general discussion of the importance and advantages of lubrication together with an explanation of the Keystone method are contained in the brochure entitled, "Keystone ABC."—The Keystone Lubricating Co., Philadelphia, Pa.

POWER CONTROL—Bulletin No. 11 describes and illustrates the "Edmoore" power demand limitator. This electrical device automatically controls and limits the power demands or peak loads on electric systems.—Edward T. Moore, 500 Cahill Bldg., Syracuse, N.Y.

BATTERY CHARGING EQUIPMENT—Battery charging control and protective devices are set forth and illustrated in bulletin GEA 817.—General Electric Co., Schenectady, N. Y.

LIGHTING—The 1927 edition of the Holophane Datalog, compiled by the Holophane engineering department, contains much information of interest to prospective buyers of lighting equipment.—Holophane Company, Inc., 342 Madison Ave., New York, N. Y.

CARBON BRUSHES—Catalog No. 5 contains engineering data covering the various grades of brushes manufactured by this company.—Electro-Nite Carbon Company, Philadelphia, Pa.

HEAT SAVING APPLIANCES—"A Word to the Wise" is the title of a booklet describing the Heat-Cop. heat saving appliance.—Heat-Cop. Corporation, Mutual Bldg., Richmond, Va.

TRANSFORMERS—Leaflet 20331 describes single-phase, platform mounting transformers for from 2,300 to 66,000 volts, ranging in capacity from 201 to 500 kva.—Westinghouse Electric and Manufacturing Co., East Pittsburgh, Pa.

ELECTRIC HEATERS — The complete line of Chromolax air heating equipment is illustrated and described in Bulletin C-108.—Edwin L. Wiegand Co., 422-First Avenue, Pittsburgh, Pa.

UNIT HEATERS—Serial 70 gives dimensions and performance data on Autovent unit heaters.—Autovent Fan & Blower Co., 730-738 W. Monroe St., Chicago, Ill.

GEARS—A collection of bulletins with loose-leaf binding describes the complete line of Sykes cut gears, of herringbone and straight-tooth types, speed reducers and a considerable amount of engineering data concerning gears and reducers.—Farrel Foundry & Machine Co., Buffalo, N. Y.

FIRE DETECTING EQUIPMENT—"Automatic Fire Detection" is the name of the new booklet describing the Garrison Automatic System.—Garrison Fire Detecting System, Inc., 79 Madison Ave., New York, N. Y.

MOTORS—Form No. 651 illustrates the construction of the stator and field windings on Century Type RS motors.—Century Electric Co., 1806 Pine St., St. Louis, Mo.

UNIT HEATERS—A folder illustrated a number of applications of Ilg unit heaters and their construction. — Ilg Electric Ventilating Co., 2642 N. Crawford Ave., Chicago, Ill.

MELTING POTS—A new leaflet, No. L-1868-B, has been released describing the Westinghouse automatic electric melting pots.—Westinghouse Electric & Manufacturing Co., East Pittsburgh, Pa.

METAL HOSE—The 12 page bulletin No. 201-29-C contains illustrations, data and descriptions of Cory seamless metal flexible hose.—Chas. Cory & Son, Inc., 183-87 Varick St., New York, N. Y.

ELECTRIC DISTRIBUTING APPARATUS — Catalog No. 27 describes and illustrates the "Bull Dog" line of electric power and light controlling and distributing apparatus.—Bull Dog Electric Products Co., Detroit, Mich.

SAFETY STAIR TREADS—Various applications of Wooster safe groove treads and security nosings are set forth in folder 14-d-1.—The Safety Stair Tread Co., Wooster, Ohio.

BELTING—A catalog and belting reference book of leather belting, belting accessories, mechanical leathers and leather specialties has been released by this company.—Chicago Belting Company, 113-125 North Green St., Chicago, Ill.

FIRE BRICK—The October issue of the Laclede-Christy Bulletin contains some interesting installation of fire brick made by this company.—Laclede-Christy, St. Louis, Mo.

COMMUTATOR STONE—Folder S2 announces the advent on the market of the new Acme Oxidizing Stone for commutators and collector rings.—Green Equipment Corp., Monadnock Block, Chicago, Ill.

TRAMRAIL SYSTEMS—Several interesting installations of Cleveland tramrail systems are described and illustrated in Folder No. TR 557.—Cleveland Electric Tramrail Division of The Cleveland Crane & Engineering Co., Wichcliffe, Ohio.

SHORT-CENTER DRIVES — A 16-page booklet, entitled "The Trend in Transmission," contains a brief discussion of engineering fundamentals and progress in the development of power transmission, with especial attention to the use of short-center drives. — Pullmax Division, Bird Machine Co., South Walpole, Mass.

WIRE ROPE — A brochure entitled "Modern Wire Rope" contains interesting data on the various types of wire rope and their application, together with engineering data required in their use.—Williamsport Wire Rope Co., Williamsport, Pa.

EXPANDED METAL — A folder shows by sketches 25 practical uses for Steelcrete industrial mesh in the plant.—The Consolidated Expanded Metal Co., Steelcrete Bldg., Wheeling, W. Va.

FLEXIBLE STEEL MATS — The use of the Acme mat in oily or slippery places around machinery is covered in a circular. These mats made in rolls are also used for conveyor belts, it is stated. —Acme Steel Co., 2840 Archer Ave., Chicago, Ill.

TRUCK CASTERS—Construction of the ball-bearing swivel and roller-bearing wheel in the Bond Ajax swivel truck caster is given in booklet R-5.—Bond Foundry & Machine Co., Manheim, Pa.

FIRE EXTINGUISHERS—The complete line of Fyre-Fyter carbon-tetrachloride, foam, and soda-acid fire extinguishers are described in a 32-page booklet.—The Fyre-Fyter Co., Dayton, Ohio.

RESISTORS — Bulletin 940 gives electrical characteristics and other data on the Type H nickel-alloy resistors and discusses their application.—The Electric Controller & Mfg. Co., Cleveland, Ohio.

FLEXIBLE FIXTURE HANGERS—Bulletin 2102 describes and prices the various types of Crouse-Hinds flexible, fixture hangers. — Crouse-Hinds Co., Syracuse, N. Y.

SAFETY SLINGS — Illustrations showing uses of some of the various types of wire-rope slings for handling loads by cranes are given in a four-page folder. —Murray Safety Sling Co., Inc., 34 Water St., Pittsburgh, Pa.

OIL SWITCHES AND CIRCUIT BREAKERS—Engineering data on the Type E-20 Condit oil switches and circuit breakers of three-pole, 60-cycle rating, for 400 amp., 2,500 volts or less, in the manually-operated, automatic or non-automatic types, for flat surface mounting, are given in bulletin 472. — Condit Electrical Mfg. Corp., Boston, Mass.